A

VOYAGE

Of the Late

King of *Sweden*,

And another of

MATHEMATICIANS,

Sent by Him: In which are discover'd

The Refraction of the Sun, which sets not in the *Northern* Parts, at the Time of the Summer Solstice, Variation of the Needle, Latitudes of Places, Seasons, &c. of those Countries.

By Command of the Most Serene, and Most Mighty Prince, *Charles* XI. King of *Swedes*, *Goths*, and *Vandals*.

Faithfully Render'd into English.

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TO THE

Moſt Serene, and Moſt Mighty Prince and Lord

Charles XI.

King of *Sweden*, *Goths*, and *Vandals*; Great Prince of *Finland*; Duke of *Schonen*, *Eſtland*, *Liſland*, *Carelen*, *Bremen*, *Verden*, *Stetin*, *Pomerania*, *Caſſuben*, and *Vandalia*; Prince of *Rugen*; Lord of *Ingria*, and *Wiſmar*; Palſgrave of the *Rhine*; Duke of *Bavaria*, *Juliers*, *Cleves*, and *Mons*, &c. &c.

My moſt Gracious King and Maſter.

Most Serene KING,

AND MY

Most Gracious LORD,

BECAUSE it Pleased Your Majesty, most Serene Prince, to lay Your Commands upon me, to Write both in our own Language and *Latin*, what we observed in a late *Northern* Journey, concerning the Elevation of the Pole, and other things of that Nature, I have there-

therefore for a few Weeks paſt, ſince our Return, daily deducted ſomewhat from my Publick Concerns, that thereby I might moſt humbly Obey the Commands of Your Moſt Serene and Royal Majeſty. But as the Nature of Mathematical Sciences is ſuch, that they depend upon Eaſie Uſe and Exerciſe, but require a more difficult Invention and Demonſtration; ſo our Obſervations are made in fewer Hours than Demonſtrated. The diſtinction of the little Wheel into its known Parts, gives but ſmall Trouble to the Clock-Maker; but the manner of dividing is not his, and but difficultly Invented. Even Boys at preſent do mutually teach one another Arithmetick; but the

Practice of it hath been Intricate, the Rules being altogether drawn from the very depths of Mathematicks. The Maſters of that Art will peradventure wonder, that at this day the Mathematicians ſolve the more difficult Problems by the help of Addition ſolely; but when they have gotten the Key they will ceaſe any further to admire it. For the Ignorant Plough-man will play you upon his Inſtrument any *French* Air, juſt as well as the moſt excellent Muſician, provided he have but the Key of it. In a word, all Artifices which owe their Births properly to Mathematicks, are of the ſame Nature. And becauſe very many not well skilled in this Learning; and not ſuf-

ſufficiently accuſtomed to diſtinguiſh the Truth of Senſe and Reaſon, have rendered Philoſophy only ſenſible; and by this Error of theirs, have rendered the way to ſolid Learning in other Sciences alſo very abſtruſe and difficult; therefore Mathematicians have reſolved never to admit of any thing whatſoever, without clear and perſpicuous Demonſtration. How imperfect the knowledge of our Senſes is, when deſtitute of Reaſon, the Sun being elevated above the Horizon in the whole World may teach us; which yet reaſon dictates to be otherwiſe placed. I have therefore expounded the Doctrine of Refraction, and other things not altogether ſo unknown more at

large than was absolutely needfull. And it is well that our Observations come forth in both Languages, tho' our Mother-Tongue might have been sufficient for our Countrymen; as it is now usual for the *French*, *English*, and other Nations of *Europe*, to express Arts and Sciences to their Countrymen. And yet because very many Foreigners have laid the Seat of their Fortunes in *Swedeland*; and, besides that, there be divers People of the Subjects of Your Most Serene Majesty, who speak a Language only proper to themselves; the *Latin* Tongue being familiar to all in the *European* World, wil best fit every one of them in Particular.

Lastly,

Laſtly, becauſe Foreigners born under another Climate and Soil, have a deſire to learn ſuch things from us; as not long ſince, both the *French* and *Italians* undertook this Journey, not without the greateſt labour; ſo, Great King, ſomething will redound to the Immortality of your Name, from this Obſervation not only begun, but likewiſe perfected under the Auſpicious Influences of your moſt Serene Majeſty. The World is not ignorant, that God hath adorned and accumulated your Majeſty with Endowments of all ſorts, which we falling into the other Extreme do more ſparingly commend; whilſt ſtudiouſly ſhunning the Mob of Flatterers ſo much deteſted by your Majeſty, with a tacit

cit Veneration only honour every Perfection drawn from the heap of your Imperial Vertues: Outlandiſh Men will not be ſilent in it; nor ſhall after-Ages neglect to extol it to Heaven with the juſteſt Praiſes. As for what concerns this little Work, I ought not to conceal that it is not only below Mediocrity, but I am ſenſible will be far beneath the Hopes of your moſt Serene Majeſty: For ſince the Time that your Majeſty unexpectedly impoſed the Province upon me of a moſt different Nature from this Affair; for ſome Years together I threw away the Rule and Compaſs, as unprofitable Inſtruments for the Courſe of Life which was then to be taken; and hid thoſe old

Maſters

Maſters in a certain Corner of my Library, which ſtill fills up a little Room in my Houſe at *Upſal*; but now endeavouring to wipe off that filthy Ruſt from my Mathematical Inſtruments, which they had contracted by lying by, I have made it my Buſineſs, that rather Power than Will ſhou'd be wanting in me ſo far diſtant from my Books; and becauſe a great Strife amongſt your Subjects in the Veneration of your Serene Royal Majeſty grows daily warmer; as for me, the leaſt ſhare of them, if I cannot act equally to the reſt, yet certainly will never ſuffer my ſelf to be outdone by any in Obedience, Reverence, Obſervance, ſubmiſſive Reſpects, and a devoted Diſpoſition.

ſition. To the very laſt I will humbly implore the Divine Majeſty of the Supreme God, that he will vouchſafe perpetually to preſerve your Majeſty, the Glory of Kings, (given from Heaven to promote his Honour, and conſerve our Country) healthful, vigorous, undiſturbed, and chearful to us, and to them that are, and ſhall be born of us: So wiſhes, and will ever pray,

Of Your moſt Serene and Royal Majeſty,

The Eternally, moſt
Devoted Servant,

John Bilberg.

In

In Solſtitium æſtivum à

Sereniſſimo, Potentiſſimoque

PRINCIPE,

CAROLO UNDECIMO,

Suecorum, Gothorum, Vandalorumque REGE,

In TORNEA Urbe ſpectatum expoſitumque à Celeberrimo Viro JOANNE BILBERG.

TOrna, vetus ſeptem ſed nunc nova fama Trionum,
Ultima Botniaci quam maris unda ferit:
Grande tibi ceſſit, præſens quod ſuſpicit ævum,

Quodque

Quodque canent ſemper poſtera ſecla, decus.
Nuper Hyperboreum propius cum viſerit axem
CAROLVS, Auguſti ſideris inſtar habens;
Quaque iit, in plauſus ſeſe utraque ſolveret Arctos,
Et nova conciperet gaudia totus apex:
In te, pervigilem, nocturno tempore, Phœbum
Vidit, pro patria pervigil ipſe ſua:
Vidit inocciduo radiantem lumine vultum,
Perpetuoque die tum ſua Regna frui.
I nunc, quicunque es, noſtris atque objice terris
Æternumque gelu, Cimmeriumque chaos.
Hæc lege, quæ narrat Bilbergius, (Is quoque tantæ
Spectator lucis, Rege jubente, fuit)
Cognoſces quanto fulgore hic ferveat æſtas;
Quantaque naturæ munera mitis alat.
Cognoſces, quam pura fluat, qua veſcimur, aura;

Quam

Quam ſit, quod colimus, non ſibi ſegne
ſolum.
Ut nulli faveat Titan impenſius oræ;
Majores nuſquam ducat ut ille moras.
Hibernæ noctes tolerentur, & aſpera bru-
mæ
Omnia nam redimit ſolſtitiale jubar.

THE

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A VOYAGE

Of the Late King of *SWEDEN*, &c.

CHAP. I.

The Obſervation of His moſt Serene Royal Majeſty.

IN the Ancient and Learned Ages, when it was the greateſt Strife amongſt Men, that Eternity ſhou'd accompany the Glory of Arts and Sciences, they were carried in a ſhort time to the heighth of Learning; for

the *Romans* emulated the *Greeks*, the *Greeks* the *Ægyptians* and both of them the *Chaldæans*; but they all both imitated thoſe who went before them, and were Examples to ſuch as did follow: Only *Epicurus* gloried that he had no Maſter; and that he made the way for himſelf unto Truth; but that is the happineſs of few People, and rarely falls out in our Times: We think it is excellent well for us, if we commendably follow; nor do we wonder that the things which are hidden deeply, ſhou'd be ſlowly diſcover'd; for ſuch is the nature of our preſent Age, that Men avoid Difficulties, and treat lighter Matters with a ſlight hand, and are ignorant of very many things which they think they know, not ſo much thro' weakneſs of Judgment as Lazineſs. 'Tis apparent, almoſt to all Men, not only to Philoſophers, but Unlearned, that the Sun, the Moon, and other Stars of this viſible World, keep the Courſe which the Wiſdom of the Supreme Deity ordered from the beginning; and no body is ſo ſilly as not to underſtand, that at ſet times they return to illuminate the ſeveral Parts of the World; for

it

it is well known, that the Earth ſometimes is torpid with the ſharpeſt Cold, and bound together with the hard Froſt; and ſometimes in one and the ſame place of the World is inflam'd with the burning Heat of the Weather, and thereupon undergoes its various Viciſſitudes; and Experience joyned to Reaſon doth ſufficiently, and too much confirm, that no other Cauſe can be aſſign'd of that Matter, than the departure of the Sun, its return, and various Scituation; but that ſome Countries ſhou'd burn with the continual Heat of Heaven, and others grow hard with a perpetual Cold, and yet equally afford Advantages to their Inhabitants, is that which many Philoſophers have call'd into Queſtion; and is not at this Day believ'd, but by thoſe who have found it by Experience. It would be a pleaſant ſight to behold the Earth in an Abridgement, to view the Scituation of it, its Form, and Bounds; ſome Parts very well Peopled, whilſt again ſome others are frequently void of Inhabitants, thro' the violence and extremity of Cold or Heat, for there are many altogether as great

Strangers in their own, as Foreign Countries; and if they know any thing by the Relation of others, yet they themſelves are almoſt Ignorant of the Matter; and hence it is, that very often they judge wrong of the Condition, both of their Native and other Countries: wherefore, ſeeing it is now long ſince, that it ſeemed ill for Men to be Ignorant both of their own and Outlandiſh Climates, by degrees a certain Deſire ſeized upon Noble Souls, by Voyages and Learned Studies, to render this Knowledge familiar to them. Without this culture of the Mind no Perſon cou'd have eaſily and ſoon perſwaded us, who live in the remoteſt *Northern* Countries, that there are ſome People who have perpetually their Days and Nights equal; or theſe laſt, that we ſhou'd undergo ſo different Changes, to wit, that we ſhou'd be ſometimes deſtin'd to a perpetual Night; and again, under our ſometimes unſetting Sun, have no room left us for Darkneſs; but that they ſhou'd rather cry out,

Triſte

Triſte ſolum, ſterilis, ſine fruge, ſine arbore tellus,
Frigus iners, illic habitant, pallorque tremorque,
Et jejuna fames.——

Sad Soil, Earth barren, without Fruit or Tree,
Cold, Paleneſs, Shivering do Inhabit thee,
And meager Hunger.——

The Induſtry of that *Italian* is to be commended, who not long ſince view'd our *Northern* Parts, with curious reſearches. I am willing here to make uſe of his Words, out of his Manuſcript, that by his Example, we may confirm our own, and invite others to do the like Matters. *In queſta* (ſaith he) *Zona glaciale boreale, biſogna ammirar la Providenza di Dio, nel vider il Sole, che per ſei ſettimane reſto ſobre dell' Orizonte, formando a queſta regione non arco ma Corona, è coſi la Luna e le Stelle; ma queſte non apparono per hora, cedendo al primo luminare, e campeggiono poi altretanto tempo circa il Solſtitio hiemale, coſi loro*

permettendo quello con la ſua contenanza: Pare in un certo modo che ſia degno di non minor oſſervatione e maraviglia in queſt' effetto il ſole, di quello che ſarebbe ſe ſi vedeſſe arreſtar il ſuo corſo, come nel tempo di Joſue, overo retrocedere, come in quello d' Ezechia, inſegnando S. Agoſtino nel decimo della città di Dio, che: Quamvis miracula viſibilium naturarum videndi aſſiduitate viluerint: tamen cum ea ſemper intuemur, inuſitatiſſimis rariſſimiſque majora ſunt. *Che ſe all' hora fece il giorno alcune hore più longè dell' ordinario, che lo ſo per ſettimane e moſi, ſi come ho detto, onde pare che di queſto ſpecialmente ſi verifichi il detto del Salmo:* Ordinatione tua perſeverat dies. *So far hę.*

But our Weakneſs, not to ſay Lazineſs, cauſes this difficulty of Believing in many; who are very ſeldom perſwaded that the things are true, which our Countrymen, and the Inhabitants of this Kingdom, tho' of very good Repute, relate concerning the various Viciſſitudes of the Year in diſtant places. Nothing certainly being a greater Impediment to a right underſtanding, than the prejudicate Opi-

Opinions of our Infancy, which having ſuckt in with our Mother's Milk, and an ill Education, we can hardly at laſt lay aſide in our Old Age; for who does not, that I may uſe this Example, perſwade himſelf that he lives in the upper part of the Earth, and the higheſt place of it; that others dwell on the ſides, or if he can apprehend it, on the bottom of it? And yet 'tis certain, that ſome do Inhabit Countries farther diſtant from the Pole, and others live in places nearer to it. The Experience of thoſe who Travel by Land or Sea, convinces us of this, which to deny or oppoſe, is the ſign of a Mind either Diſtracted, or altogether Perverſe. Hence it is, that of late more Credit is given to ſome illiterate Sailors, who having ſail'd round the World, have aſſerted that it is round, than to thoſe Ancient Divines and Philoſophers, who contended that the Form of the Earth was not ſo, only that they might gain a greater Strength to their Authority and Doctrine. Certainly we admire, that Men eminent for Learning, at the very mentioning of whoſe great Names we pay reſpect, ſhou'd ever fall

into ſo abſurd Opinions. *Tertullian* and *Auſtin* thought that they were over-wiſe, who taught that there were any *Antipodes*. Others Ridiculouſly.

Τόσσα δὲ ῥινὸς ὕπερθεν ἀραιῆς οὐκ ἀναφύσω.

And Poſterity perhaps will be ſurprized, that we, at this time of Day, are ignorant of many, and thoſe not ſo difficult Matters neither.

And further, I do believe it is agreed amongſt all *Virtuoſo's*, and ſuch as are given up to Ingenuous Studies, that from the firſt Moment the Creator of the World gave to the Sun, as to the Ruler and Governour of the Day, a motion ſo equal and conſtant to it ſelf that every where by equal Circumvolutions, it makes alſo alike Courſes; and produces ſometimes equal, and ſometimes inequal Shadows, and as much as in it lies in places alike, produces effects alike alſo; from whence it comes to paſs, by the great Providence of God, that the Sun warping towards either Pole at ſet times, regulates the Days and Nights, and gives Light or Darkneſs to Countries, to be eſti-

eſtimated by the Spaces of Hours, of Days, or of Months; and it ought to ſeem a Paradox to none, that the People who dwell under the Equator, and have their Days and Nights perpetually equal, ſhou'd not have longer Days than thoſe, who if they live under the very Poles, will reckon one Night to be of ſix Months, and the oppoſite Day to be equal to it; and that thoſe who are ſcituated between the Æquator and the Poles, however they divide their time, reckon alſo ſo many Days and Nights to be meaſured in the ſame Spaces.

No Mathematician is ignorant, that thoſe who live about the 65th. degree of Altitude, have their whole Day in the Summers Solſtice of 24 Hours; or which is the ſame, at that time the Sun doth not ſet as well from Natural as Optick Cauſes, before the 66th. degree be compleated: But very few Mathematicians have drawn this Knowledge from the Experience of their own Eyes; from whence it comes to paſs, that tho' the Inhabitants of the Country ſhould aſſert this to be true, yet in this Point they wou'd not gain Credit from ſuch as urge only

only Natural Cauſes; and beſides, the Variety and Diſagreement of the Relaters increaſes the obſtinate doubts of the Incredulous, ſince, after the Vulgar way, ſome mix incredible Things with Truths. This Aſſertion mov'd the moſt Serene Prince *Charles* the 11th. the moſt Potent King of *Sweden*, *Goths*, and *Vandals*, and our moſt Gracious Sovereign, when the laſt Year he viewed theſe Regions; who, as he is endowed by the Supreme Deity with a truly Divine and Admirable Wit, and adorned with all the Gifts that are moſt proper for his Royal Poſt; ſo he delights to make the exacteſt Scrutiny into all things, and to diſcuſs every one of them in particular, and to give as much credit to every Perſon as he deſerves; ſo being now deſirous to try with his own Eyes, what Truth there was in the common Report of the People, and whether they did really ſee in thoſe Places a Sun which ſets not: He was then in the City *Torneo* in *Weſtro Botnia*, ſcituated about 65° and 43′ of Latitude; whoſe Horizon, altho' it was in part hinder'd by Mountains and Woods, ſo that the Truth of this Matter

cou'd

cou'd ſcarcely be diſcovered upon the plain ground; and beſides, it being ſome Days after the Summer Solſtice, we might doubt the opportunity of ſeeing it was ſlipped; however the undaunted Heart of the moſt Invincible Monarch, never fatigu'd by any Labours, conquer'd all theſe Difficulties: A little Tower being ſhow'd to us of about One hundred Foot high, on which the Bells of the Church of the City are hung; he gets up into it by Ladders, and thoſe very ſteep, accompanied with ſome Eminent Perſons, as Curious Witneſſes of this Obſervation; amongſt whom by Name, were Count *Guſtavus Douglas*, Governor of the Northern Provinces, *Charles Piper*, Secretary of State, and the Secretary of War, *John Hoghuſen*: In the Year M DC XCIV. on the 14th. of *June* we view'd the ſame until Eleven a-Clock and 53 *M.* at Night; at which time a little Cloud covering the Sun by little and little, it diſappear'd; but about the 12th. Hour, and 6th. Minute after Midnight, or of our following Day, which was *June* the 15th the Sun paſſing again

out

out of the ſmall Cloud, ſhined out very brightly; from whence it is certain that it did not ſet in the mean time, but that Cloud was the only Cauſe why it was not diſcerned all Night long; the Experience of the Inhabitants confirm it, who always at that time of the Year, when the Weather is clear, uſe to ſee the Sun all the Night long: The moſt Serene King himſelf did not diſdain to put down with his own Hand into his Table-Book this Obſervation; which when the reſt of the Company had neglected, they were ſurprized the next Day at the admirable Exactneſs of the King, in an Affair ſo foreign to Royal Concernments, and his moſt exact and Mathematical Diligence; and being aſham'd for the Neglect of it, and that they were outdone by their King in ſo ſmall a Share of Trouble, they humbly and ſubmiſſively beſeech'd the King, that they might have a Copy of his Obſervation; His moſt Gracious Majeſty readily granted their Requeſts, and gave leave to all thoſe who deſired to take a Copy of it. This way the Royal Obſervation came to the joyful Hands of his

his Subjects; and by the Care of the moſt Illuſtrious Governor of that Country, Count *Guſtavus Douglas*, may be read in Golden Letters upon a Table faſt'ned to the Wall, near to the Altar of the Church in that City; and leſt any thing ſhould be wanting in our Teſtimonial, for the Credit of the Tranſcribers, behold a Confirmation.

I *Underwritten do teſtifie this Deſcription wholly to agree with the Obſervation of his moſt Serene Majeſty, written with his own Hand,*

Torneo, June 15. 1694. John Hoghuſen.

Certainly a Monument fit for Poſterity to admire, and to propoſe to themſelves the Sedulity, Care, Vigilance, and incredible enduring of Toils of ſo great a Prince; for who being intent, and expoſed to mighty, not to ſay Royal Fatigues, can endure to deſcend to ſo minute, ſo unuſual Matters? And ye Sons of the Mathematicks whoſe Talent it was to fetch ſuch things out of their ſecret

ſecret Places, and to demonſtrate them; You, I ſay, ought to bluſh, and publickly acknowledge that your Science hath received this Improvement, not from your ſelves, but from the moſt Potent King.

Our moſt Gracious King having viewed theſe Countries, as he deſigned; and having travelled ſome Tracts of Land, inhabited by ſuch People as either ſpeak, or underſtand the *Sweediſh* Language; and at length being come amongſt other Nations, uſing only the *Finland*, or *Lapland* Tongue, uſed by few in the World, returned with great ſpeed according to his uſual Cuſtom. After his Return, amongſt other things, he relates to his Subjects, who enjoy a milder Air, and more fertile Soil, the incredible Varieties of Days and Nights, which he had ſeen in the moſt Northern Parts of his Kingdom; not only where the day at that time is continual by the Preſence of the Sun, but alſo where they live in Summer-time without any Night, by the perpetual Twilights; and affirmed that he had ſpent a continued Day without

without any Night, a thing before heard, but not at all believed by him; and when that Buſineſs, known to very few, render'd all of them doubtful who were ſo attentive to his Majeſty's Diſcourſe, ſeveral Queſtions were ſtarted, which exerciſed the Belief of ſome, and the Judgment of others: Thereupon our Mathematicians are conſulted, whether really under that Elevation of the Pole, ſuch Phænomena's were to be expected; and which were the true Cauſes, why in thoſe Places the Body of the Sun did not ſet: But they moſt humbly anſwer'd, they believed it might be ſo through divers Natural Reaſons to be determined by the Scituation of Places, Temper of Air, and other Changes; but as yet not at all underſtood by them, having never lived under that Elevation of the Pole, but only giving Credit to their Land-Maps; which being often made and corrected, cannot always merit our undoubted Belief in all things; but that every Aſtronomical Obſervation ſhould be ſo made, as to anſwer the Celeſtial Obſervations, and beſides illuſtrate them; and they all to be confirmed

med by Geometrical Demonſtrations, that they may ſhew their Readers ſuch Reaſons, as do not perſwade, but force them. By this means the Science of Aſtronomy had its Riſe, Progreſs, and no ordinary Increaſe, firſt from the *Aſiaticks*, then from the *Europæans* for many Ages, by the indefatigable Labour of the Obſerver. In the Northern World, the Inhabitants being ſtudious of War, and Arms, that Science did not lye altogether neglected, as appears from the Grave-ſtones, and *Runick* Calendars, with other very Ancient Monuments; however it was not cultivated with a Care that might equal that of the *Chaldæans*, or the Ancient Mathematicians in *Greece*: Nevertheleſs, by the Grace of God, theſe Ages owe their Happineſs ever ſince the moſt Bleſſed Times of the Reformed Religion, to Kings of Pious and moſt Glorious Memory; and eſpecially to His moſt Serene Royal Majeſty, which by a Paternal Affection, and truly Majeſtick Love for Learning, and Men of Letters, by his incredible and inexhauſted Magnificence to them, hath brought not only the Mathematicks;

but

but all ſorts of Sciences to that pitch, as neither we cou'd hope, or Foreigners believe, they cou'd ever attain to; and yet a great deal of Work is ſtill remaining, and there will never want an occaſion to any who ſhall be born a thouſand Ages hence to add ſomething. For many things, according to the Conjecture of the wiſe *Roman*, are reſerved for future Ages, when the very Memory of us ſhall be worn out: Theſe things and others of the like Nature, diſcourſed they, not without Pleaſure, before His moſt Serene Majeſty; who, after conſidering them more deeply, carefully weighs with himſelf the Force and Effects of Nature; and tho' he did not diſtruſt his own Eyes in the Obſervations once made, yet that he might gain the Conſent and Confeſſion of all, and lay open the true Series of Cauſes, reſolveth to ſend thither ſome Mathematicians about the ſame time of the following Year, that ſo they might note every thing diſtinctly, and duly obſerve the differences of Motions, with the true Riſings, and Settings of the Sun, and what they were with Refraction

or without it. In the mean time, his loyal Subjects made a Medal to the moſt grateful Memory of that ſo fortunate Royal Expedition, with the Picture of the King, and an agreeable Emblem.

CHAP.

CHAP. II.

An Account of the Longitude of Places.

NOW therefore in the preſent Year, 1695. in the Month of *April*, this Charge is committed to me by His moſt Serene Royal Majeſty, that I ſhould undertake the Journey, together with the moſt Illuſtrious Perſon, Mr. *Andrew Spole*, the moſt ingenious Mathematick Profeſſor in the Univerſity of *Upſal*, and now almoſt ſuperannuated, my Companion and Aſſociate in the Journey, and formerly for eleven Years my moſt pleaſant Collegue in this ſort of Studies; and that we ſhou'd omit nothing that might conduce for the making of theſe Experiments, or any other of this Nature; and above all we were injoined ſo to haſten our Journey, that we might be in the City *Torneo*, where

the King's Obſervation was made, not only ſome days before the Summer-Solſtice, but alſo that we ſhou'd go farther to the Northward, where we might ſee the Sun higher above the Horizon in the North Meridian, by reaſon of the greater Latitude of the Place: Thus we departed from *Upſal* with Hearts and Souls reſolutely fixed, on the 21ſt. Day of *May*, Old Stile, which is uſed in our Country, at a Seaſon unuſual, and not yet fixed, by reaſon of the Unſeaſonableneſs and Rigour of the Weather; and therefore with great Difficulty we paſſed through *Upland*, *Geſtricland*, *Holſingland*, *Medelpadia*, *Angirmarnland*, and *Weſt Bothnia*, being for the moſt part in theſe laſt Countries detained by Ice and Snow; eſpecially in paſſing over Rivers and Arms of the Sea, which are there in great Plenty, and ſometimes ſo wide, as to be 1000 Paces over; in which not only the Rapidity of the Rivers, and Fierceneſs of the Winds, but alſo the Ferry-Boats are to be minded, leaſt they be ſevered aſunder; for two Boats placed at a certain diſtance from one another, make a Ponton, into which

a Charriot is to be ſo put with Horſes, that the fore-wheels reſt upon one Boat, and the hind-wheels on the other; the Oars being fitted on both ſides: And in the high way the ground being ſometimes ſlippery, and the Horſes and Charriots ſticking in dirty Places, created us great Trouble, where the Cold being partly diſſipated, yet the Earth did not return to its former Solidity and Firmneſs; for at this Seaſon the Creeks neareſt the Shore being hardn'd with Froſt and Ice, and many Pines being cut down, and diſpoſed into order, did even then repreſent a Winter-Journey, the Froſt being melted, and thawing near the Bank-ſide only, ſo that no body cou'd go any further of the Journey with Safety; and therefore almoſt all by Land, the way being as yet not well beaten; wherein being toſſed by divers Fortunes, at length we happily arrived at *Torneo* on the 6th. of *June*, having made a moſt hazardous Voyage in ſixteen Days, in Charriots, Boats, or on Horſes, and a-foot by turns.

The City *Torneo* is ſituated by the River *Torneo*, riſing in *Lapland*, a very pleaſant Place, which the River makes, by parting it ſelf into two Arms, and joining again where it diſcharges it ſelf into the Sea, from which Iſland the Citizens aſſert the City to have received its Name at the time of its Building: But it was founded in this Iſland in the Year of our Lord M DC XX. when before it was the Seat of Inhabitants, who dwelt ſome Furlongs from it to the South, where there is ſtill an old Stone-Church; for they have a wooden one in that City, and that curiouſly built, as generally is uſual in other Cities of that *Country*, not long rebuilded. This City trades chiefly with the *Finns* and *Laplanders*, whoſe Language the Citizens underſtand well: In the Winter they likewiſe give them a Viſit with their Ram Deer; and for the Merchandize which they carry with them, receive others from the *Laplanders* of equal Value: They have alſo no inconſiderable Commerce with the *Moſcovites*, who yearly ſell their Goods to them, and part with them at a very reaſonable

reaſonable Price; ſince thoſe which are brought out of the City *Archangel*, lie them in leſs, when the Concourſe of the *Hollanders* is the greateſt. The ſame Evening that we came to *Torneo*, we obſerv'd the Sun above the Horizon, noting the Time by the going of a moſt exact Clock, which ſhew'd Minutes and Seconds, which I had for that uſe, by the Favour of the moſt excellent Count, and Royal Senator, *Nicolas Gyldenſtolp*, by this at 11 *h.* 15′, 45″, the Sun was hidden in a little Cloud, paſſing over it, and appeared that Night no more to us.

On the *7th* of *June* we found the Altitude of the Sun, by two Braſs *Aſtrolabes*, exactly divided into *Deg.* and *Min.* One of which we wou'd have to be looſe, and the other fixed with the Perpendicular, by which the Errors which ariſe by the Diſpoſition, might be the more eaſily detected; and by this Means we took Care that the very leaſt difference of them ſhou'd not eſcape us; nor was any Calculation made by us, except the Inſtruments agreed moſt exactly. The ſame day in our firſt Obſervation, we

found the greateſt Altitude of the Sun to be 47°. 48′. On the 8*th* Day we found the *Meridian* Altitude to be 47°. 49′. The 9*th* Day was Cloudy. On the 10*th* it was 47°. 50′. from which repeated Obſervations, and another more made in the ſame place at our return, on the 18*th* of *June*, when the Suns *Meridian* heighth had decreaſed to 47°. 45′. we gathered by an Aſtronomical Calculation, the true Motion of the Sun being conſider'd, and the juſt Parallax added, that the Elevation of the Pole in that City is not ſo much, as is laid down in ſome Geographical Tables, eſpecially thoſe of Foreigners, being but 65°. 43′. but no account ought to be had of the Refraction in theſe Obſervations, the Body of the Sun being elevated beyond that degree where they ceaſe; we deſired truly to confirm theſe Diurnal Obſervations by the fixed Stars; becauſe to thoſe who obſerve by the Circumpolar Stars, the Altitude of the Pole uſes to come out leſs; and the Winter and Summer Declinations of the Sun being otherwiſe equal, the Hypotheſis of the fixed Obliquity of the Ecliptick being granted;

but

but amongſt the more Northerly, at ſeveral Times are render'd inequal by reaſon of their Refractions; but at that time the Light of the Sun, and its continual Preſence ſaved us that trouble.

The Latitude of *Torneo* being found, we were ſolicitous to find out the true Longitude of it; but ſeeing that cou'd not be Aſtronomically obtain'd, by any direct Journey, by reaſon of the Situation of Places, we were forced to be ſatisfied with the Reports of the Land-Surveyers, who have ſo exactly deſcrib'd the Meaſures of the Ways, and the Situation of all the Countries and Counties, by the Command of His moſt Serene Royal Majeſty, and becauſe amongſt the ſeveral Ways of finding out the Longitude of Places, eſpecially at Sea, for which the States of the United Provinces promiſed ſo great a Reward to the finder of it, all Eyes being intent upon this Victory, which is not as yet obtain'd; I ſay, amongſt ſo many ways, no Invention hath yet appeared more excellent than that which is performed by the help of a Pendulum; of which that Noble *Hollander*, *Chriſtianus Conſtantine*

ſtantine Huygens, was the Inventer and Author; a Perſon, as well for his other Famous Works, as for the ſake of this, moſt worthy of Immortality. And here it came into our Heads to admire the great Conſtancy of theſe Portable Clocks, made after that Example, two of which I brought with me from home, accurately diſtinguiſhed with an Horizontal Pendulum, and divided into Minutes; but the Third, having alſo Seconds, was added to them at *Stockholm*. Before our departure I ſo diſpos'd theſe Two for three Weeks together, to the Motion and Meaſure of a moſt correct, exact Pendulum of three Foot, which was ſuch a Rule for me, that I cou'd ſcarce doubt of their Exactneſs; ſince in the whole Journey they went ſo equally, that they did not differ from one another ſo much as one Minute at the ſame time. But it moved me more than I can expreſs, in the firſt Obſervation at *Tornea*, when the Suns greateſt Altitude, and from thence the true place of the South was known to us, all theſe Three Clocks wanted only 18 Minutes of this Point; to wit, the *Automaton* ſhewed

the

the Hour of the Day of the *Meridian* from whence I came, and to which I was joined when I departed at Twelve a Clock, and yet cou'd not rightly ſhow us the *Meridian* of *Torneo*; or to agree with it, becauſe that City is judged to be ſome Degrees more *Eaſterly* than *Stockholm*. For of the Mapps which I now have, one of them, which *Ægidius Valkenier* put forth in a leſſer Form, makes the Longitude of *Stockholm* 35 Degrees, and 30 Minutes, but of *Torneo* 40°. 0', this difference of the *Meridians*, 4°. 30', gives the Intervals of Time 18' Aſtronomically computed: The other of *Fred. de Witt* makes the Longitude of *Stockholm*, 36°. 20'. but of *Torneo* 41°. 10'. This difference of the *Meridians* 4°. 50'. makes the meaſure of Time betwixt them 19'. 20". A third of *Scandinavia*, by the ſame *De Witt* makes the Longitude of *Stockholm* 39°. 00. but that of *Torneo* preciſely 44°. 00. which is the greateſt, and produces the difference of the *Meridians* of five Degrees; whence alſo in Time the difference of *Meridians* is given 20 Minutes. But which of theſe two Tables is the latter

and

and truer is not certain; for in Maps and Clocks the Age of them is not expreſſed, on purpoſe that ſo they may always ſeem to be New; but howſoever it was, theſe three Maps did not differ ſo very much from one another, nor from the Scope which I propoſed to demonſtrate; for if the firſt Map pleaſe, that agrees exactly with my Clocks, which were ſo much too ſlow; and it is plain, that the ſecond differs only in one Minute, and twenty Seconds; the third differs two Minutes; which equality of Motion and Agreement is certainly to be mightily admir'd in ſo little and portable Machines; nor did I think that it cou'd by any Accident happen, that for ſo long a time they ſhou'd mutually anſwer one another in the ſame Laws of Motion; and it is pleaſant to be employ'd in ſo delightful a Speculation; now therefore, if any ſhall deſire a further Scrutiny into it; let him alſo know that in winding up the Clock I daily loſt five Seconds; for that hath been long obſerv'd by me; as likewiſe, that 72 Beats of the Pulſe of the Artery, being Faſting, anſwer alſo to one Minute, when

when the Body is in Health, and neither bound up with too much Cold, nor inflamed with vehement Heat; which Experience, and that is wonderful, never failed me for fifteen Years together. Therefore, ſince theſe five Seconds 12 times reckon'd, make one Minute, the Clock alſo in twelve Days was too ſlow by one Minute. Now, becauſe we got to *Torneo* in ſixteen Days, add for thoſe four Days twenty Seconds, that ſo the number of the loſt may be 1′ 20″ which added to 18′ wanting at *Torneo*, makes the Sun 19′ 20″ which agrees excellently well with the ſecond Maps, as is above ſhowed; they requiring in that time the difference of ſo many Minutes. But many will be of Opinion, that the inequality of Natural Days doth much oppoſe this Calculation; for the *Apogæums* and *Perigæums* teach us, that the daily Motion in which the Sun returns from one *Meridian* again into it, is ſometimes ſlower, and ſometimes ſwifter; and that the *Anomalies* of the Plane of the Ecliptick, lying inclin'd to the Equator, may beget ſome difference of Aſcenſions; but as theſe are very little

every

every Day, and that we uſe only the Mean, we neglect ſuch a ſmall Time as a thing of leſſer Conſequence; but when it is neceſſary we alſo correct them by Tables of mean Motions made for this Purpoſe. The Companions of our Journey know that theſe things are neither precariouſly aſſerted, nor raſhly related by me; and they can honeſtly certifie, that I have often mentioned this Certainty, not without Admiration; and I will ſhow in the following Problem, why I have been ſo long on this Subject, for the ſake of thoſe who do not underſtand it; why the difference of Time in two diſtant Places ought to be equal to the difference of Longitudes betwixt them.

Let *P.* be the Pole of the World in this Diagram, *A. C.* the Æquinoctial Circle, *G. E.* ſome Parallel, *B. S.* the *Meridian* of *Stockholm*, *D. T.* the *Meridian* at *Torneo*; therefore becauſe the Sun, by its Diurnal Motion daily runs through the Æquinoctial Circle, *A. C.* and in it every Hour ſpends 15 Degrees, and by conſequence 360 in its entire Cir-

P
T
S
G
C
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D
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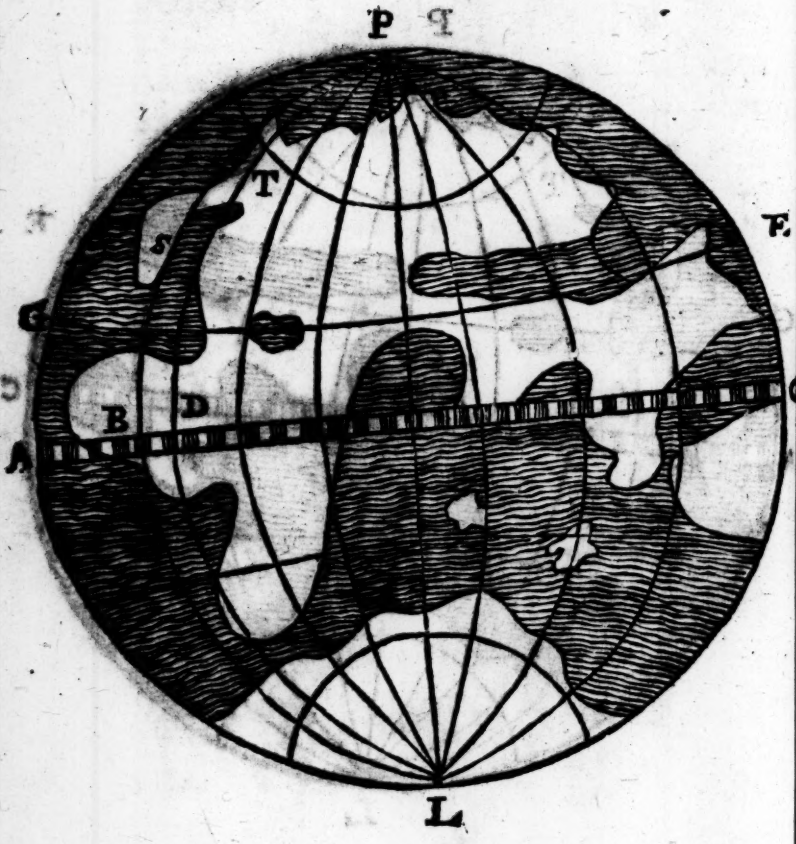
L


P
T
F
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L

Circumvolution, in the ſpace of 24 Hours. Let theſe two Places in the Queſtion *Stockholm*, *S.* and *Torneo*, *T.* be either of them under their *Meridians*; now let there be taken out of that middle Map aforementioned, the diſtance of theſe Places, 4°. 50′. when the Sun was in the *Meridian*, *D. T.* it was 12 of the Clock at *Torneo*, 19′ and 20″, after that the Sun comes to the *Meridian* at *Stockholm*, *B. S.* at which time it was Twelve a Clock there; but at the ſame time at *Torneo* it was Twelve a Clock, 19′ 20″, ſince *Torneo* is more *Eaſterly* by ſo many Minutes than *Stockholm*; and therefore it is manifeſt that the Arch *B. D.* and alſo every one of the Parallels with it to be 4°. 50′. and ſo much to be the difference of Longitude between *Stockholm* and *Torneo*, therefore the Horary difference is equal to the difference of Longitude, *Q. E. D.*

This

This is the true cauſe why thoſe who go *Weſterly* have longer Days than thoſe who go to the *Eaſtward*; for whoſoever by going from the *Eaſt* to the *Weſt*, after ſome Days paſſes into a different *Meridian*, hath a longer Day than if he had ſtayed in the ſame *Meridian*; but it matters not whether the Latitude be the ſame or different, becauſe in every Latitude it is Noon when the Sun is in the *Meridian*; wherefore thoſe who go from *Torneo* to *Stockholm* have the Day of 24 Hours, and almoſt 20 Minutes; as on the contrary thoſe who go from *Stockholm* to *Torneo* loſe ſo many Minutes in a whole Day.

It is manifeſt from their Journals, that theſe Variations was the greateſt admiration to the *Spaniards* and *Portugueze*; for theſe Sailing to the *Philippine* Iſlands with an *Eaſterly* Courſe, almoſt a Semicircle, gain'd Twelve Hours of the *Europeans*; but thoſe with a *Weſterly* Courſe had ſo many Hours of Day later. Wherefore if two Ships Sailing out of the ſame Port, go to the ſame Places, by contrary Courſes, the one to the *Eaſtward*, and the other

to

to the *Weſtward*, having Sailed a Semi-circle of the Earth, at their meeting, their Accounts do differ a whole Day from one another; but having Sailed about the whole Earth, at their return Home will find two Days difference in their Journals. It is clear from *Pliny*, that the Ancients did not want this Knowledge, who proves it by many Experiments. But eſpecially that thoſe who Sail to the *Weſtward*, although on the Shorteſt Day, can Sail faſter than thoſe who Sail in the Night, as having the Sun it ſelf for their Companion.

I thought it neceſſary to Treat more largely of theſe very well known Matters; not that I can, by my own Clocks, prove any certain Longitudes to be found out, but that in Land Journeys, they may be this way moſt eaſily obſerved. But how much we exceed the Skill of the Ancients in this Machine, no body is ſo Ignorant in Letters as not to underſtand; for the Ancients had no other way of diſtinguiſhing Times, but by Shadows, and Water-Glaſſes; the more ancient way was uſed amongſt the *Chaldeans* and *Ægyptians*, and at laſt brought

down to the *Greeks*; but at *Rome* they Learned it latelier, as we may ſee by the ſame *Plinius Secundus*: For *Scipio Naſica* firſt of all divided the Hours, as well of Nights as of Days, and ſet up an Hour-Glaſs in his Houſe in the Year, *V. C.* 595. which falls out 155 Years before the Birth of our Saviour. *So long*, ſays he, *the* Romans *had diviſions of Time*; but at length in *Octavius Auguſtus*'s Time, the manner of making Dials was taken from *Vitruvius*, which afterwards made ſo great Improvements, that now all *Europe*, which before had gotten the Victory from the other Parts of the World (whoſe Inhabitants much admire the Induſtry of the *Europeans*) daily ſtrive amongſt themſelves by new Inventions of this Machine.

How great the Variation of the Needle is in theſe *Northerly* Countries is not to be raſhly determin'd; for we by a *Meridian* Line found in the Town of *Torneo*, find its Declination from the *N.* to the *W.* to be about ſeven Degrees; for the great incertainty of the Weather hinder'd us to determine it preciſely, which ſeldom permitted us to ſee the Light

Light of the Sun, either before or after Noon; and that ſcarcely except amongſt the Clouds; ſo that a ſhadow cou'd ſcarcely be diſtinguiſh'd from a *Penumbra*; tho' it is to be confeſſed, that the time of the *Solſtices* is leaſt fit for this purpoſe: For if that matter of moment is to be ſought either from the greateſt heighth of the Sun, in which the *Meridian* Line may be had exactly; or from an upright *Gnomon* perpendicularly erected, that Obſervation may nevertheleſs be liable to Error, unleſs it be frequently repeated in the ſame place, becauſe the Shadows of the Sun neareſt about Noon are ſenſibly neither increaſed or decreaſed: The Sun however in the mean time making its Progreſs in its own Parallel.

CHAP. III.

Diurnal and Nocturnal Obſervations of the Sun.

BUT let us return to our Sun ſeen by Night; in conſideration of which, the chiefeſt part of our Labour was undertaken; in vain for ſome Nights did we watch in the Obſervation of it; the Sky being always fill'd with Rain and Clouds; but at length in the Night between the 10*th* and 11*th* of *June*, an happy Seaſon broke forth, which beyond our Expectation diſperſed the former Clouds; and that was the firſt opportunity we had to enjoy a clear Night; we therefore ſaw three Parts (almoſt four) of the Suns Body above the Horizon, one fourth only being under it; So that the Center of the Sun did really appear above the Horizon: We therefore Congratulated our ſelves in

in the Affair, for a long time believed, but before not uſual to our Eyes. Being excited by that occaſion, I joyfully compoſed the Day after the following Epigram, before we proceeded any further upon the Memory and Confirmation of the Royal Obſervation; and ſuch as it was, ſent it to *Stockholm*, to the moſt Illuſtrious and excellent Count *Nicholas Guldenſtolp*, that ſo before our return, it might appear what might be expected in that buſineſs.

Rex Carolus terras, quas Circulus Arcticus ambit,
Dum peragrat, proprias atque tuetur opes:
Miratur parere ſuis latiſſima ſceptris,
Sol ubi continua lampade luſtrat humum.
Hactenus & noſtris hæc ſenſibus invia, Princeps
Nullus, ait, Phœbum vidit inoccidiuum.
Subſtitit in votis Alphonſi gloria Regis;
Cur ſe perpetuo lumine jactat Iber?
Sobrietas ſed enim, Pietas, vigilantia, cura,
Sufficiunt Carolo munera tanta Dei.

In our Obſervation we uſed the ſame Turret, in which His moſt Serene Royal Majeſty obſerved the Sun; but leſt any one might think that ſmall heighth to be the reaſon why ſo much of the Sun was diſcerned, we choſe a Place ſome Paces from thence, not far from a Gallows, where there was a free Proſpect from the Northern Quarter; and there we found the Appearance to be no other than out of the Turret, being ſatisfied with this clear and diſtinct Obſervation when the Sun was ſo very few hours from the Solſtice, which on the following Day, *June* the 11th. by an Aſtronomical Calculation falls out 9 h. 39′ before Noon. And now we thought it our buſineſs to proſecute our Journey farther to the Northward; and to look out for a Place, where abating the Refraction, the whole Body of the Sun might be diſcerned, ſince it was clear that all that which appeared here of the Body of the Sun did appear by Refraction only; ſince beyond our Opinion and Calculation, according to the late found out Elevation of the Pole,

more

more of the Sun it ſelf was ſeen than ought to have been.

Dædalus, & fama eſt, fugiens Minoia regna,
Præpetibus pennis auſus ſe credere cœlo,
Inſuetum per iter gelidas enavit ad Arctos.

So we likewiſe being to paſs to the cold Northern Parts, did not truſt to ſwift Wings, but to Boats very ſlenderly faſt'ned together; for from hence as we go farther to the Northward, there is no more Uſe of Chariots, or Horſes; wherefore quitting our Journey by Land, we deſired the help of Pilots, whoſe Language we underſtood no more than thoſe who are moſt ignorant of it; and ent'ring into their Boats, were to ſtrive againſt the Stream of the River, which wou'd ſuffer us neither to row nor ſail, but amongſt Stones and Rocks which lay in our way, which requires only a diligent help of Boats, Poles, and ſtrong Arms to make uſe of them: Thus our Seamen paſſed along the Banks of this rocky River; and in ſome Places with their moſt vigorous Endeavours, they

ſeemed

ſeemed ſcarcely to get a Foot forward; and for ſeveral Hours to advance but ſo many Paces; and ſometimes by long bendings and turnings of the River they were forced to go aſhore, and hale their Boats out of the violence of the River, where nothing elſe cou'd be otherwiſe expected by Humane Aſſiſtance; but it ſeemed very hard, and ſtrangely unuſual to us, that on the Bank-ſide there was no room between the Thorns and Brambles, and heaps of Stones where we cou'd ſet our Feet; ſince being wearied with the Fatigue of this Haling, we attempted rather to make our Journey a-Foot, and by that means make the Boat ſomewhat quicker and lighter. And as an addition to theſe our Troubles, Mountains of Ice of twenty Cubits and more being driven together by the force of the Waters, cover'd both ſides of the River, and they alſo ſo ſloping and craggy, that every moment we dreaded their fall, together with our own Ruine: Neither was there any help for us, clinging conſtantly with the Poles of our Boats to the Shore, had not God by his ſpecial Favour vouchſafed to avert the Miſchief;

but

but if it did any where happen, that the courſe of theſe Mountains was interrupted we joyfully leaped Aſhore, admiring the Nature of the Country, which not without great Pleaſure to the Spectators, amongſt Snows and heaps of Ice produced green Herbs and Flowers, among which was a great plenty of the Lilies of the Vallies.

Amidſt theſe Wonders of Nature we looked for Men; and at length, as indeed we met with very few Houſes of the *Finns*, we were carried to a certain Countrymans Cottage, which in their Language was called *Pello*. 'Tis ſaid to be Ten old Miles diſtant from the City *Torneo*; and there was an Inn in which we might lie on Rain Dear Skins, for they make uſe of no other Bedding. However, amongſt other Inconveniencies, this was our Comfort, that in the ſaid place, neither Mountains or Woods hinder'd our proſpect from the *Northern* Board, whereby the Sun might all Night be the leſs diſcerned; and it was a particular Gift of God that the ſame Night was free from Clouds; ſince in our whole Journey we had ever a doubtful and low-

lowering Sky; therefore 'twas here that we beheld, with much pleaſure, the whole Body of the Sun, not only entire, but elevated more than two Diameters of its Body; and when we had tryed ſufficiently in this place, with no leſs difficulty we performed the reſt of our Journey; and on the 14*th* of *June* we Arrived at the Work-Houſes of Iron and Copper at *Kengis*. That Night likewiſe favour'd our purpoſe; and we ſaw the Sun from our Boats on the River, three Diameters of its Body above the Horizon.

The Situation of this place is betwen the Confluence of both Rivers, whoſe right Branch owes its riſe to the Lakes, Streams, and Mooriſh Places in *Lapland*, and thence from *Swadawara*, and perhaps further by ſeveral bendings thro' *Monier* and *Kengis*; but the left is excluded from the *Weſtern* ſide, and the Lake *Torne*, ſituate almoſt in the Confines of *Norway*, and is here precipitated with that violence thro' the tops of Mountains and broken Rocks, that the fall of the Waters near theſe Work-Houſes for Metals, is eſteemed to be 36 Feet high,

high, and that with extraordinary Noiſe, and vehement Impetuoſity; but it gives an excellent advantage to the ſaid Work-Houſes, which are ſo placed, that where the River hath a turning to the *Weſtern* Bank, it is not reſtrained with the Wears, tho' they be of conſiderable bigneſs; nor can it go over the top of them, but runs with a free Courſe, without any Cataracts to the oppoſite Bank. On the 15*th* Day, being troubled with vehement Cold Winds, and moſt boiſterous Weather, we took the heighth of the Sun, amongſt the interſperſed Clouds, with an Aſtrolabe; and at length, at Ten of the Clock 15′ looking for its Altitude with an Aſtrolabe, the Calculation being taken off, we gueſſed the Latitude of the Place to be ſcarcely more than 66° and 45′, altho' the Sun there in the Night Time ſhows it ſelf ſo largely above the Horizon, and makes its Day long enough, and with an ample Circuit. And here, when we were deſigning to go further into *Lapland*, by the right Branch of the River, which ſeems to lead ſtrait to the *Northward*, the Inhabitants declared, that it was not in the

the Power of Man to perform ſuch a Journey in Summer; for all Journeys into *North-Lapland* ought to be made in Winter; but altho' the left ſide of the River was alike open, as before for the Boats; yet it ſeem'd to us to incline too much to the *Weſtern* Shore; ſo that it was of very little uſe to us, from that ſide, to proceed one degree further; therefore ſuppoſing what we had already found out to be ſufficient for the Lovers of Aſtronomy; and conſidering the account of our Time, becauſe we were ſtinted to narrow Limits in the Journey, and had not as yet perform'd all that was to be done, we reſolved to take our Courſe homeward.

Tum verò nautæ incumbunt, & littore parvas
Deducunt ſurdo naves; natat uncta carina.

At our going away we had great plenty of Metals, which with great Care are drawn out of the Metallick Veins of *Lapland*; and thoſe rich enough in Copper and Iron, and yet not carried out with-

without great Charges, and very mighty Risques, thro' the Precipices of Waters

ἀλλά νυ καὶ τὰ
Ἄνθρωποι ῥέζουσιν ἀϊδρείῃσι νόοιο.

And some pieces of the Magnet were presented to us, taken out of the same Iron Mines, which we carried home with us. The Loadstones there have very little force; and yet in one of them, which I still keep, I perceive it daily encreases, and I hope that they will augment in time, being arm'd.

Magnets are found in the Iron Mines of *Sweden*, and elsewhere; but those of *Lapland* excell in Force all that ever I had the Fortune to meet with. I pass by other things, which we saw, or were related to us, lest I shou'd seem to give an History of the People, which others have before written: And now being gotten into our Boats, we no longer, as before with our Boat-Poles and Spreads, follow'd the Course of the Shore, but keeping the middle of the River, where it was most Rapid; the Rowers doubling their Strokes, we strove at least to emulate,

late, if not to outdo, the ſwiftneſs of the Waters; this was abſolutely neceſſary, leſt the Impetuoſity being ſwifter than the Boats Courſe, ſhou'd fill our Boat with Water, and ſo drown it with its Waves, eſpecially when the Waters a head of us, being roll'd with the greateſt violence amongſt the ſharpeſt Rocks, Whirlpools, and deepeſt Gulfs, returning with like force, ſhou'd meet the Head of the Boat, and ſo detaining it as it were in a Whirlpool, ſhou'd appear altogether to overſet it. In theſe Streights we were ſenſible

Quantoque ratem qui temperat anteit
Remigis officium; quanto Dux milite major.

By ſo much more was the ſafety placed in the Pilots of our Boats; for they Steered with that Skill amongſt the unſeen Shoals, that we were ſo amazed and aſtoniſh'd, that when we were deliver'd from Dangers, we cou'd ſcarcely believe our ſelves to be in Safety; but their Art appeared ſtill more, and eſpecially in ſome certain Places. Thoſe that

that are the moſt Experienc'd in this Voyage will witneſs, that there are ſome Precipices of this River, where the Boat is toſſed up into the Air for the ſpace of ſome Feet, the Pilot Steering in the ſame manner, until it is again in the Water. And this whole Voyage from *Kengis* to the City *Torneo*, which flows with one continued Channel, receives 29 Rivers, one of which makes a whole *Swediſh* Mile in breadth; the other being leſs, recompence their ſmallneſs by the violence and rapidity of their Waves. Neither can they be paſſed at any time, except by the moſt able Boatmen of the Place; and in one of the Rivers, altho' the Paſſengers are expert, yet they Hire an Inhabitant to be Pilot, but which is wonderful, for two Farthings only, venturing his Life; certainly a great hazzard, as we have ſometimes beheld from the Shore with horror; but neceſſity impoſed that Law on them, for this is the King's High-way, and the only one for thoſe who paſs into *Lapland* for ſometime in the Summer; but the Inhabitants who dwell near the River ſide, and thoſe but very few, as they

live for the moſt part by catching of Fiſh, never Inhabit in any other place, ſince beyond the Shore ſide, for a long Tract, all the Lands are uncultivated and horrid; and they are contented with a little Ground, where-ever any place is found fit to be ſowed; neither do they break it up with a Plough, or Plough with Oxen or Horſes, but by digging and Spades temper and bring the Soil into order by the Labour of their Hands. But at our return, we were carried by ſo ſwift a Courſe, that we came from *Kengis* to *Torneo*, a Voyage of 16 Miles, in leſs than a day and halfs time. There we immediately obſerved the Diurnal and Nocturnal Sun, trying whether the Obſervations again made did agree with the former; but becauſe it was many Days after the *Solſtice*, this after Care was of little advantage. Having therefore once obſerved the *Meridian Altitude* of the Sun on the 18*th* of the Month, we perceived it to have decreaſed to 47°. 45'. and yet from the declination of that time gave the ſame elevation of the Pole with our former Obſervations.

And

And now, Courteous Reader, you have wherewith you may exerciſe your Wit, by enquiring into the true Cauſes of theſe Apparitions. We have given you Materials, make uſe of them as ſeems fit to your Judgments; but by your leave we interpoſe ours alſo, moſt freely ſuffering every one to abound in his own ſence. What therefore appertains to our Nocturnal Obſervations, and the true aſcenſion of the Sun above the Horizon, becauſe it cannot be underſtood by all without the premiſed Doctrine of Refraction, which is the moſt ſubtil part of the Science of Opticks, we will briefly lay down ſome things for the uſe of Students, whereby they may with greater eaſe take our Demonſtrations.

CHAP. IV.

The Doctrine of Refraction.

MAny are the Arts and Sciences which owe their beginnings to Chance and Fortune; which wou'd be long and difficult to reckon, ſince their firſt Originals are unknown, and their Progreſs made by little and little, which renders us doubtful both of the Order and Manner in which they began. Firſt of all it is very certain, that we learn by Experience, that the Rays which proceed from any viſible Body, if they fall from a more denſe Body upon a more rare, or on the contrary (which Philoſophers uſe to term a different *Medium*)

dium) at this Entry the Ray proceeds no more ſtrait forward, but is Refracted, and in its paſſage gets another way different from the former. This Aſſertion is proved many ways; but leaving the more ſubtil, we will explain it in a vulgar way not unknown to all People. Let ſome bright Piece be put into an empty Veſſel, as Gold or Silver Money; whereby the ſplendid Ray may more eaſily repreſent the image to the Eye; then let him that makes the Experiment go ſo far from the empty Veſſel that the Money being at the bottom is ſo covered with the Edges of the Veſſel, that it cannot be diſcerned, let him ſtay in that place, and order Water to be poured out of another into this Veſſel; which being done, the Money will appear through the Water to him in that Poſture, being inconſpicuous before; and that ſo much the higher as the Water is put in in greater plenty, by which it may be underſtood, that this viſive Ray between the Money and the Eye is only Refracted in the higheſt Superficies of the Water, ſince a right Ray cannot be carried to

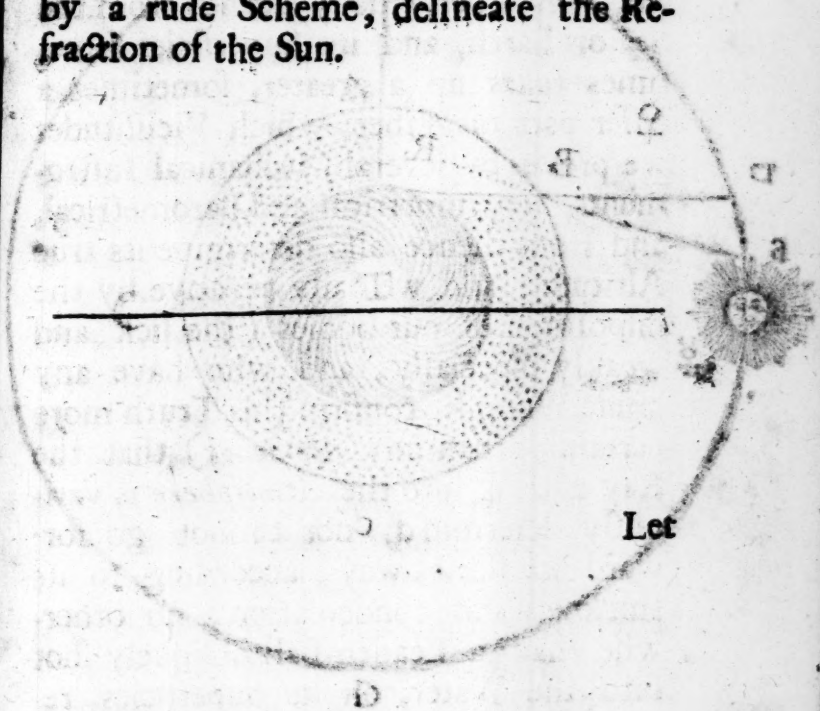
the Eyes, remaining in the ſame Poſture, from the Money, by the Opake ſides of the Veſſel: The reaſon is the ſame, when an Oar ſeems to be broken in the Water, where no other Cauſe can be given of this Fallacy of the ſight, than the Inclination of the Ray of the things ſeen, from that ſide in which it enters a different Medium. Wherefore ſince the Solar Rays are right Lines, it is doubted, not without cauſe, if the Sun, and other Lucid Bodies in Heaven, be any where or every where diſcerned in their true places; but ſince it is for certain obſerved in the Eclipſes of the Luminaries, that the places of the hidden Bodies, both true and apparent, are different not only by reaſon of the Parallaxes, but alſo Refractions, the ſtrongeſt Argument of Aſtronomical Truth, and beſides, ſome other Obſervations moſt deſerving Credit, takes away all Doubts.

Since therefore, by conſent of all Men, it is evinced, that the Air is neareſt the Earth, whoſe Particles going out from the Earth are the Cauſes almoſt of all the

the Viciſſitudes which happen to it from natural Motions; and we think do ſcarcely exceed, or not much tranſcend, the higheſt tops of Mountains (and that is it which we call the *Atmoſphere*) but next to this the Ætherial Air ſucceeds, diffus'd through the whole Univerſe, in which the Sun, and fixed Stars, and all Planets are moved; and yet there is not the ſame tenuity and purity of both of them: For the Ætherial Region (the ſpaces of Shadows which proceed either from the Earth, the Moon, or Planets, or Comets excepted) is wholly in the Rays of the Sun, and Stars; and is ſo ſplendid, that at Night its ſplendor may be perceived by us, dwelling in the ſhadow of the Earth, altho' the Interval betwixt us and the fixed Stars be ineſtimable, by which this Splendor, with the difference alſo of Colour, is tranſmitted to us, but is always open to the Rays of them, except when 'tis obſcured by the Atmoſphere, but the Air ſwelling with ſmoaky and thick Exhalations, drawn from the Terreſtrial Globe by the help of the Sun, and ſubterraneous Fire, ac-

cording to the meaſure of the Matter is ſometimes thicker and ſometimes thinner, both in divers, and in one and the ſame place, but at divers times, to wit, that Matter, being rarified or compreſſed, which perpetually aſcends from the Sea or Earth, and its Superficies ſometimes takes up a greater, ſometimes a leſſer part of Æther, which Viciſſitudes we prove by ſeveral Mechanical Inſtruments, Hygrometrical and Barometrical, and from thence alſo determine its true Altitude; and we daily perceive by the diſpoſition of our Bodies (the ſick and weakly eſpecially, and who have any crude Wounds, confirm this Truth more certainly than any *Almanack*) that the Ray entring into the *Atmoſphere* is variouſly determin'd, nor cannot go forward in ſtrait way, according to its thickneſs and condenſation, no otherwiſe than a Leaden-Ball obliquely ſhot into the Water, on its Superficies, recedes from its firſt direction, loſing ſome of its ſtrength in paſſing through a different *Medium*; or as a Nail driven through two Boards, not contiguous enough,

nough, acquires one determination in the intermediate Air at the end of one, and another at the entrance of the other Board; these things being more largely Premised than was intended, we will, by a rude Scheme, delineate the Refraction of the Sun.



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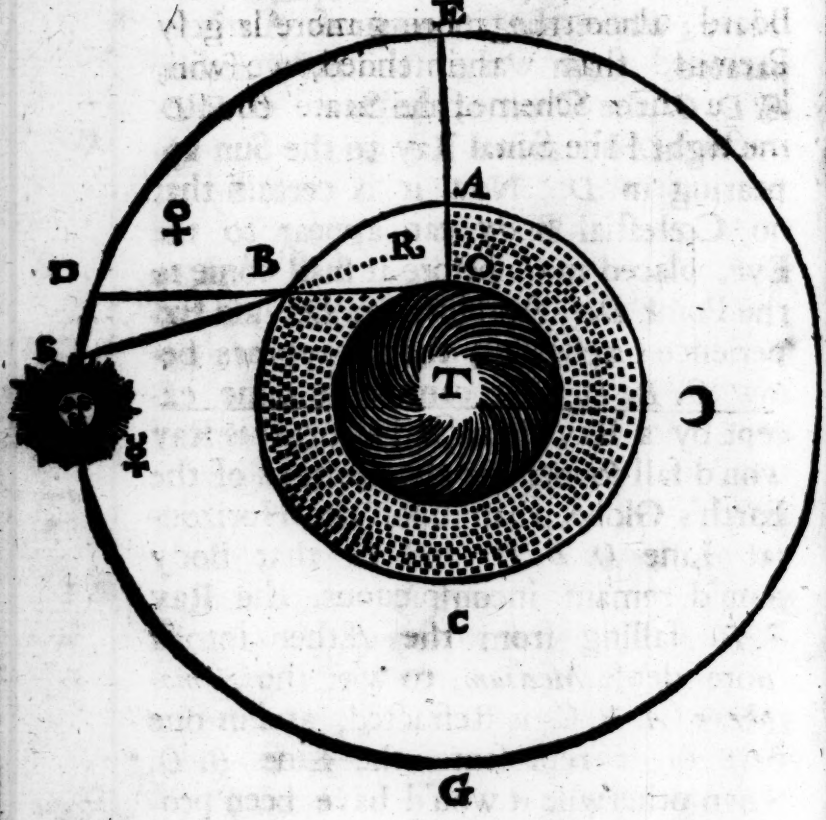
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Let *T.* be the Center of the Earth, *O.* the Eye on the Plane of the Earth, *A. B. C.* the Superficies of the *Atmosphere*, where the more groſs Air is ſeparated from the thinner Æther. *E. D. G.* the Orbit of the Sun. *O. B. D.* the right Horizontal Ray to the Sun appearing in *D.* Now it is certain that no Cœleſtial Body can appear to the Eye, placed in *O.* before it ſhall come to the Point *D.* And further, becauſe Experience teaches us, that it appears below *O. B. D.* that cannot be done except by a Ray Refracted; for this Ray wou'd fall ſooner on the Convex of the Earth's Globe, than upon the Horizontal Line *O. B. D.* and ſo that Body wou'd remain inconſpicuous, the Ray *S. B.* falling from the Æther into a more denſe *Medium*, to wit, the *Atmoſphere A. B. C.* is Refracted, and in one part of it repreſents the Line *B. O.* when otherwiſe it wou'd have been produced to *R.* if the *Medium* had been the ſame, but not to the Eye, *O.* Hence it is certainly concluded, that the Sun appears on the Earth, ſometimes before its Riſing, when it ſeems to be diſcern-

ed

ed by us in an Horizontal Line, *Q. E. D.*

But becauſe it is manifeſt, that the nature of Refractions is divers, and that the Rays falling perpendicularly upon the Superficies of a different *Medium* are not Refracted, as if the Ray from *E.* ſhou'd fall upon the *Atmoſphere A.* it reaches to the Eye *O*, directly and without any Refraction; but thoſe which fall obliquely, are by ſo much the more Refracted, by how much the more they recede from the Perpendicular; hence it is manifeſt, that the Cœleſtial Bodies, nearer to the Horizon, appear under a greater Refraction, and therefore appear higher than the more remote, which come nearer to the Perpendicular. Hence the Rules of Refraction are by the Mathematicians derived to a certain Degree, for the Sun and Moon, even to the Degree of 38 Altitude; but for the fixed Stars, but to the Degree of 20. which Rules would never fail, if the diſpoſition of the *Atmoſphere* was everywhere the ſame; but this variety is not

in

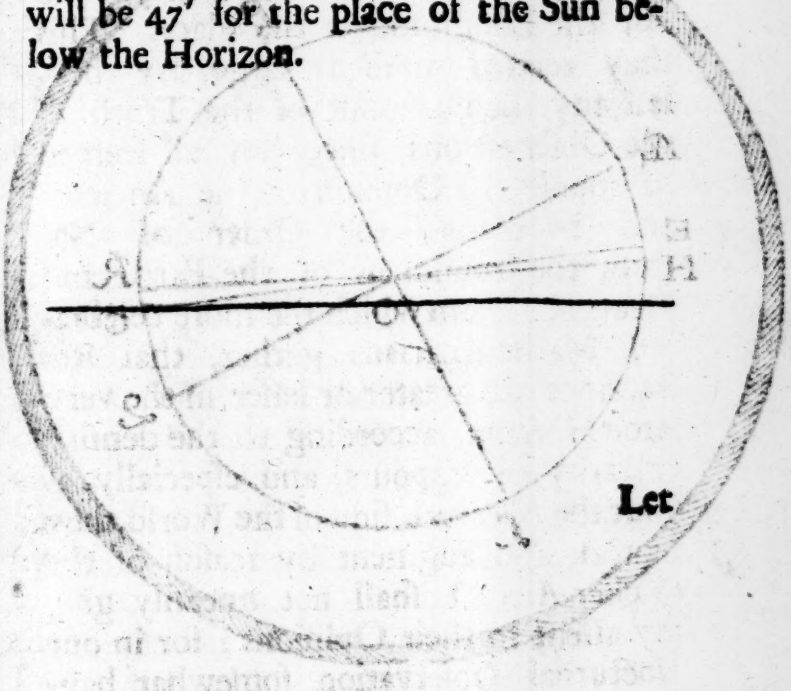
in the leaſt to be neglected, becauſe that Refraction cannot in all Parts of the Earth be equal, but is found to be greater in places nearer to the Pole than that which is in the more remote, which may be confirmed by the ſole Experience of the *Hollanders*; and that Example is wont to be produced, as moſt true, by all, even the moſt excellent of Mathematicians, ſince there are but a few Obſervations in places near to the Pole, which we may uſe in examining the *Phænomena*; for the *Dutch* Wintering in *Nova Zembla* ſaw the Body of the Sun above the Horizon, at the time when it ſhou'd have been four Degrees below the Horizon, which certainly is a Paradox; for by this reaſon the Horizontal Refraction encreaſed too much beyond the quantity commonly allowed in the Tables of Refractions.

Very many therefore not undeſervedly ſuſpected this Obſervation of the *Hollanders*, and yet they themſelves are compelled to confeſs that thoſe Obſervers were Learned in Aſtronomy, ſo that they cou'd not commit ſo great an

Error

Error in their Observation. Certainly the exact noting of the Time by a corrected Clock; and that hindered by the Frost, by an Hour-Glass of Twelve Hours; as also the conjunction of the *Moon* and *Jupiter*, observed by them, by which compared with *Ephemerides*, they found out the Longitude of the Place. This they related more at large, say they, lest any shou'd doubt of the Truth of the Observations, since they all seemed to oppose the Opinion of the Ancients and Moderns, the Order of Nature, the roundness of the Earth and Heaven. From which the more celebrated Mathematicians gather, that Refractions are greater or lesser in the very same Horizon, according to the density or rarity of Vapours, and especially about the *Northern* side of the World, they increase and augment by reason of the thicker Air. I shall not uneasily give my assent to their Opinions; for in our Nocturnal Observation somewhat happened altogether like it, for let the found-out Elevation of the Pole at *Torneo*, 65°. 17'. that being taken from a Quadrant

drant 90°. gives the Complement of the Elevation of the Pole, 24°. 17′. now becauſe the Obſervation was made about the time of the *Solſtice*, the Sun being in the beginning of *Cancer*, if the Declination of the Ecliptick, which is commonly 23°. 30′. be taken from it, the reſidue will be 47′ for the place of the Sun below the Horizon.



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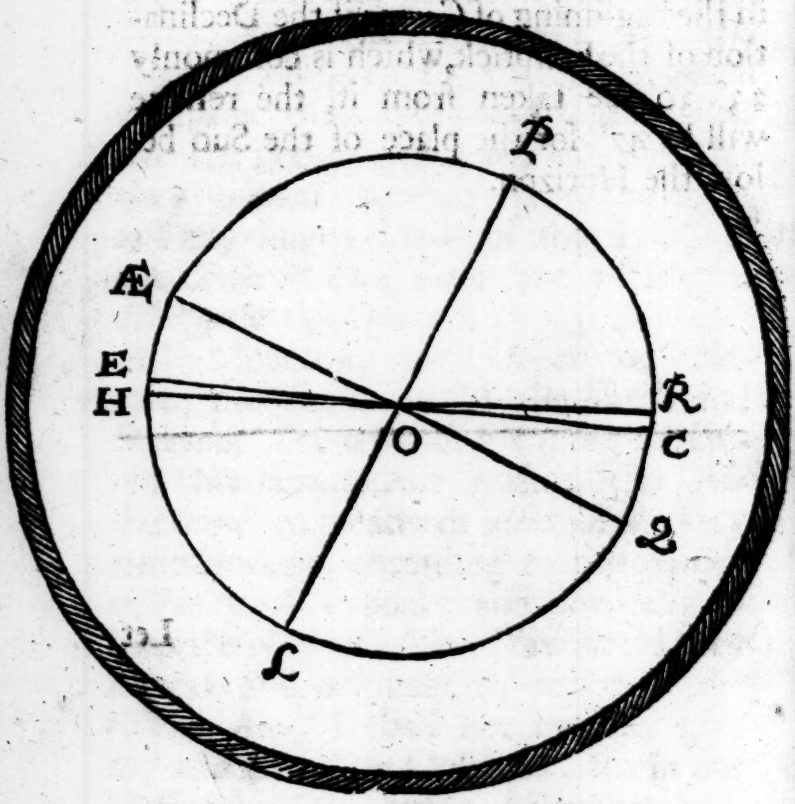
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Let *P Æ L Q.* be the *Meridian* at *Torneo* in this Diagram, *P L.* the Axis of the World, *Æ Q.* the Æquator, *H R.* the Horizon, *E C.* the Eccliptick, the Angle *P. O. R.* the Elevation of the Pole, *R O Q*, its Complement, *C O Q.* ſhall be the Declination of the Eccliptick *R O Q.—C O Q.= R O C.* that is to ſay, the place of the Sun ſhall be 47′ below the Horizon, *Q E D.*

Now becauſe the Diameter of the Sun, at that time of the Year is ſuppoſed by us, about 30′. to which the Horizontal Refraction may be equal in the Opinion of thoſe who think the *Tychonick* Tables of Refractions are greater than they ought, by reaſon of his aſſuming the Suns Parallax too bigg. Let it be either by his Table, or that of *Lansberg*, 34′ for the difference is ſmall in either of them, the Sun ſhall be ſtill depreſſed below the Horizon, altho' it ſhou'd appear in its Center, being Elevated above the Horizon, three fourth Parts of its Body, to wit, 22′ 30″. Since there-

fore there is so great a difference between Diurnal and Nocturnal Observation, it follows, that here the Horizontal Refractions are far greater than in those Places where the foresaid Tables were made; but to form an exact Rule for them is an hard Work, and of no few Years, as we learn from *Tycho*'s Tables, composed by a long use from the Risings, Sittings, and Culminations of the fixed Stars.

And further it appears from this our Observation, that they who place *Torneo* beyond the 66 Degree of Latitude are mistaken. For if it be laid down to be only 66° 30'. then 66° 30'. = 90°—23° 30'. But when this number is the Declination it self of the Ecliptick, by this Hypothesis the Sun will also be Elevated one half above the Horizon, without Refraction, when its Center is in the Horizon it self; but adding the usual Refraction, the inferiour Limb will be Elevated at *Torneo*, above 19° which yet contradicts Observations.

In

In the little Cottage *Pello*, where we ſaw the Sun at Night two Diameters, or 60 Minutes above the Horizon, by *Tycho*'s Rule of Refractions, which makes the Refraction 34′ in the Horizon, and in one Degree above the Horizon 26′, it is eaſily concluded, that the Sun is diſcerned in its whole Body without Refraction, for the Sun being elevated two Diameters or 60 Minutes above the Horizon, its Center will poſſeſs 45′. But in that Altitude let the Refraction be proportionable to 34′ and 26′ or 30= to the Diameter of the Sun, therefore its lower Limb will appear without Refraction 15′ above the Horizon; but if we aſſume, as it is fit, a greater Refraction ſome Particles of the Solar Body will alſo be elevated in this place by Refraction: But at *Kengis*, where it was diſcerned in three Diameters of its Body, it appears by what hath been demonſtrated, that the Sun was ſeen without any Refraction at all, to which end we are willing to delineate in one ſcheme, the Nocturnal Obſervations,

which we had at that Seaſon in three Places, that the inexperienced in Mathematicks may judge more rightly of them, and underſtand their true and genuine Senſe.

Let *T.* be the Globe of the Earth, *B F G.* the Horizontal Line, *K A B C I.* the Suns Orbit, *F E D H.* the Quadrant of the Atmoſphere, *G.* the Eye in an Horizontal Plane, *C D G B E G. A E G.* the Refracted Rays, *A G F.* the Angle of 47 Minutes, the reſt ſucceſſively leſſer; for the firſt of the Sun obſerved at *Torneo* is under the greateſt Refraction; the ſecond at *Pello* a little leſs; the laſt at *Kengis*, leaſt of all; whence it follows, that the Sun ſeen by Refracted Rays in the Points *A. B. C.* does not make the Lines *F A. E B. D C.* drawn from the Points of Refractions Parallel, further it is clear that the Sun at *Torneo* in *D.* was below the Horizon by Refraction at *A.* but being Refracted at *Pello* from *E.* to *B.* ſome part of its Body was really ſtill beneath the Horizon, altho' it appeared

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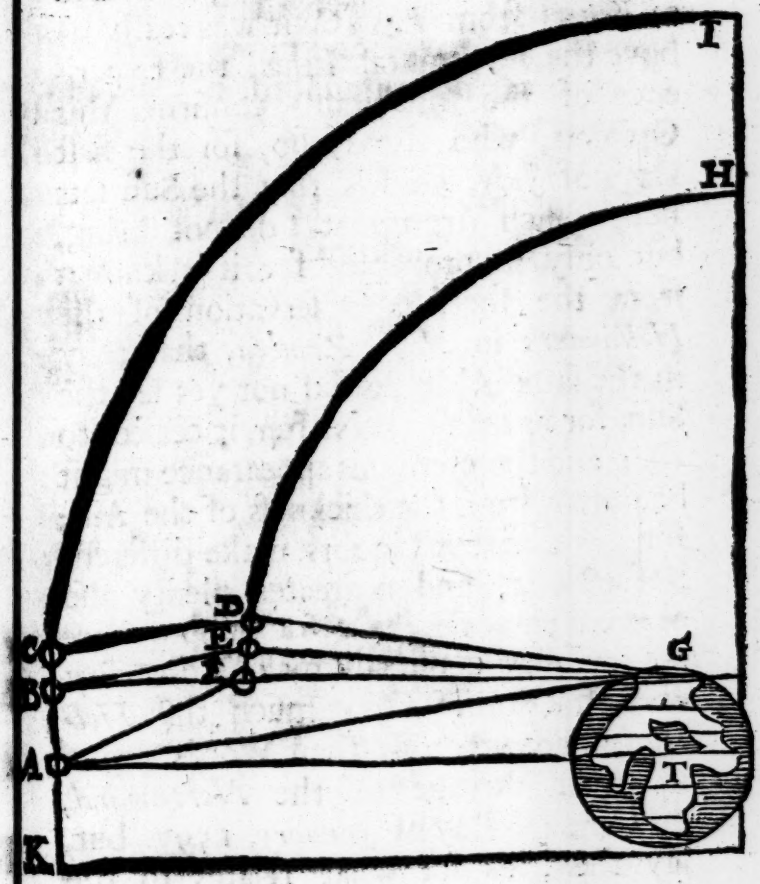
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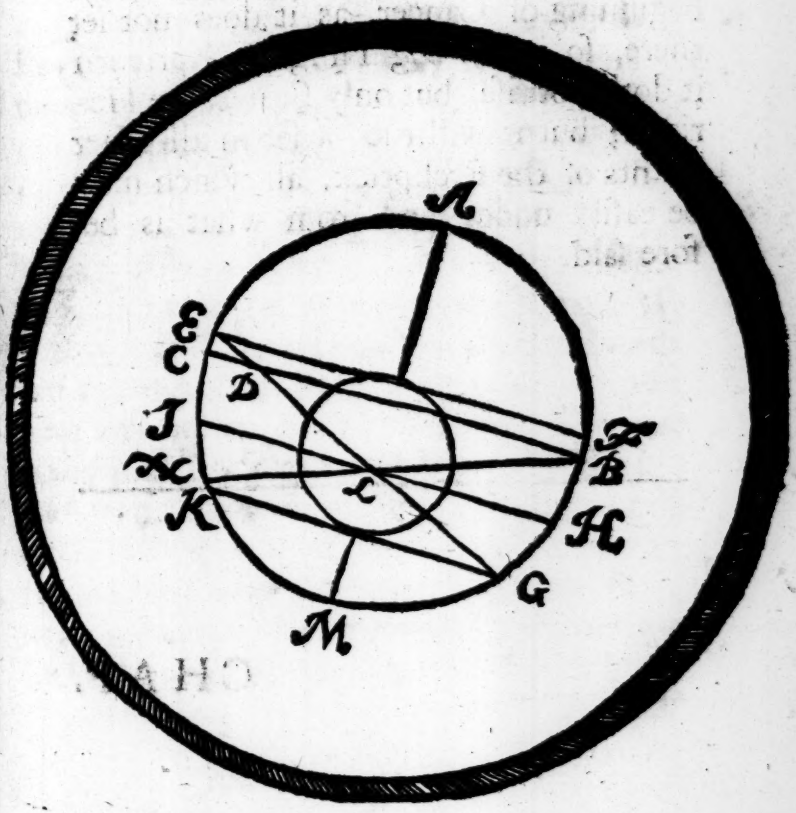
two Diameters, or a whole Degree above it in *E.* *Laſtly*, being Refracted at *Kengis* from *F.* to *C.* it was really above the Horizontal Line; the Experience of the Inhabitants confirms this Opinion, who there alſo, for the firſt Days of *July*, confeſs that the Sun ſets not; which Argument I do not bring, but only as probable; for it is known from the foreſaid Obſervation of the *Hollanders* in *Nova Zembla*, that they in the ſame Altitude did not yet ſee the Sun for ſo many Days after it ceaſed to riſe; and therefore this appearance might be drawn from the thickneſs of the Air; for (as different Liquors make different Refractions, and a greater plenty alſo of them encreaſes the Refraction) a more rare or more denſe will make a diverſity of Refractions. How much the *Hollanders* admired this, their Words prove in their Voyage to the *Northward*, on the 24*th* Day of *January*, 1597. but, ſay they, as for what relates to the Matter it ſelf, as God is wonderful in his Works, ſo we refer it to his Omnipotence, and leave it to be diſcuſſed by others,

others, *viz.* That the Sun under the foreſaid Altitude of 76 Degrees diſappeared to us on the fourth of *November*, and on the 24th of *January* was again ſeen by us. For the reſt, there is no doubt but a right Judgment may be made Aſtronomically from the Altitude of the Sun of its ſtay above the Horizon, even not attending to Refractions, which alike diſpatch this buſineſs; altho' in the determination of Climates, I do not ſtill deny that it is Controverted amongſt the Mathematicians, whether any notice is to be taken of Parallaxes and Refractions, ſome aſſerting, and others denying it. But waving theſe things, and neglecting Refraction, the longeſt Day in *Kengis* is found to be of about 30 of our Days, by the ſole Calculation of Climates.

In this Diagram, let the Pole be *A*, the Elevation of it *A. B.*, *B. C.* the laſt Parallel in which the Sun is carried above the Horizon; *H. I.* the Æquator *B. N.* the Horizon, *B. L. H.* the Angle of the Complement, *E. L.* of the Pole, *E. F.* the Tropick of Cancer, *G. K.* the Tropick of Capricorn, *E. G.* the Eccliptick, *D.* the Point where the Eccliptick cuts the Parallel *B. C.* which Arch being doubled, gives the place in which whilſt the Sun tarries, by aſcending to the Tropick, and again deſcending to the Parallel, it does not reach the Horizon, but that whole Line will not ſet.

The reaſon is the ſame of any place within the Arctick Circle, according to its different Latitude, even to the Arctick Pole, that the Sun Yearly does not riſe or ſet for ſome Days; and by ſo much the more as the Places are nearer to the Pole; ſo that in the place of the Pole it ſelf it does not ſet for an whole half Year, and does not riſe all that time


A
E
C
D
J
F
B
H
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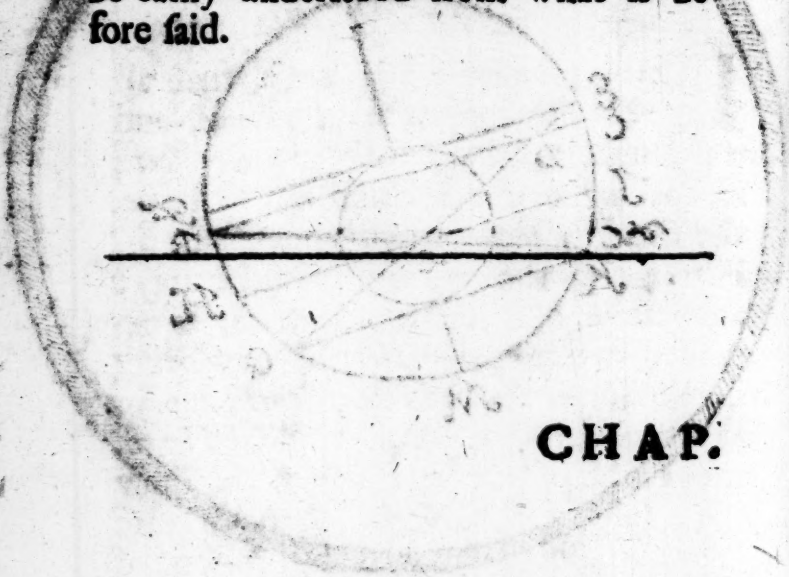
G
M

time in the place oppoſite to it, but in the furtheſt places follows the Courſe of the Tropicks; for the Sun being in the beginning of Cancer, as it does not ſet there, ſo in the beginning of Capricorn it doth not riſe, but only ſweeps the Horizon; but it will riſe or ſet in all other Points of the Eccliptick, all which may be eaſily underſtood from what is before ſaid.



CHAP.

CHAP. V.

Of the Conſtitution of the Frigid Zone.

Laſtly, We muſt not omit, that all the time we were at *Torneo*, and the further places, we were *Periſcii*; for ſo long as the Sun did not ſet to us, the Shadow was carried about into all Parts; and the Sun being in the upper Semicircle of the *Meridian*, it was extended towards the *North*; but being in the lower towards the *South*, but in ſo little an Elevation of it to the *North*, the Light of the Sun cou'd not ſhow the Hour of the Night on our Dials: Without doubt as well by reaſon of the Paralleliſm, with the place of the Dial, becauſe it was ſcarce above its Plane; as alſo becauſe of the thicker Vapours about the Horizon. There

is

is ſome difference between Obſervations made at Land and at Sea; ſo that even they who are in a leſs Latitude of place, ſee the Sun all the Night, which very many Inhabitants of *Weſtern Bothnia* confirm to be true to their Knowledge, in the Cities of *Bithea* and *Buhlea*, and other Maritine Places; for beſides that, the Horizon ſeen upon the Waters is even, being hinder'd by no Inequalities, which at Land the Mountains or Trees uſe to make. I alſo think, that Reflection comes neareſt to Refraction, which being joined in a double manner, repreſents the Species of the Solar Body, no otherwiſe than happens in Looking-Glaſſes, where the firſt Reflection without Refraction, is made in the poliſhed Superficies of the Glaſs, but the other in the bottom of it, in its filed bottom, but with Refraction; which Compoſition, except you take heed, ſhows to you one thing ſometimes falſly, under a double Image, or ſomewhat greater than it ſhou'd be; and further, many things may be Objected about the Mari-

Maritine Obſervations of Peaſants; and we very often want the Confirmation of Fiſhermens Sayings, who being accuſtomed to ſpread Probabilities for Certainties, ſometimes both egregiouſly deceive, and are deceived; yet we will admire it the leſs, becauſe Mathematicians, as well in their Cœleſtial as Terreſtrial Obſervations have ſomething that is Human in them.

In the Frigid Zone, and its Neighbourhood, the ſtay of the Sun above the Horizon, brings this Advantage to the Inhabitants, that the Corn in thoſe Places ripens in a ſhort time; for as we have heard from the Husbandmen in fertile and fruitful Years, not above ſix or ſeven Weeks are required amongſt them, from the time of Sowing their Corn until Harveſt, we made no difficulty to ſuffer our ſelves to be perſwaded of it, when the firſt Sower, as we went, was in the City *Torneo*, and the Barley ſown in the beginning of *June*, or the 16*th* Day of the ſame Month, was grown beyond Expectation;

on; and the Grass, which as we passed by some places of *Western Bothnia*, in the beginning of *June*, had scarcely come out of its Stalk, at our return, after four Weeks was Mowed. But this Advantage is followed by another Disadvantage; for the Corn is liable to much danger from the Cold, in this so short a space of time; for if it do but happen about the time when it ripens, or when they hope it shou'd ripen, that the Dew or Frost falls upon it in the Morning, it hurts the Grain, and wholly destroys it, which Mischief they cannot otherwise prevent, than by cutting the Corn unripe, before it so suffer. Even then they did conjecture, that they shou'd experience this Year the same Damage, not without the greatest prejudice to them; and the event showed that they were not False Prophets; for altho they saw the Cold to be near, yet the Corn was not then come to that Maturity, as it cou'd be exposed to any inconvenience by the violence of the Cold Weather.

But

But here is one thing which I wou'd have my Courteous Reader to obſerve, that the Nature of theſe *Northern* Countries is not altogether to be eſtimated from the Intemperateneſs of this Year, for the preſent Year exceeds all others that are paſt in the Memory of Man, for the ſeverity of the Seaſon; and there are very long lived Men in thoſe Places, who ſometimes live to an Hundred and more Years; but not one to be found amongſt them who cou'd teſtifie that Thunder is ſo much as once heard in the Year, and eſpecially in the middle of *April*, which now happened and ſeemed to preſage ſomething unuſual: And it is very remarkable, that when our moſt Serene King went to ſee theſe Places, the Year before, the Inhabitants never ſaw a more pleaſant Time, as if the Countenance of Heaven was compoſed for Mirth, the Lord of the Country being preſent.

As for what concerns the Iſlands of the *Bothnick* Sea, they underwent a different Fortune; for as we went from *Torneo*, to the Pariſh *Calix*, in our Voyage on the 19*th* of *June*; at our Arrival at ſome little Iſlands, we there perceived that the Soil was not yet freed from Cold; nor did the Birch-Trees, which are very many, in that place, ſhow any ſign of Greenneſs; when yet in other Places beyond Sea, they abounded with their ripe and full grown Leaves; and we know, that this is not alſo unuſual in other Countries, ſince in *Japan*, whilſt the ſharpeſt Winter continues, and the Snows and Rains continually fall, other Countries of *Aſia* and *Europe*, ſituated under the ſame Climate, are not ſenſible of the ſame hardneſs of Winter.

And

And *Nova Albion* being ſituated about Forty Two Degrees *North* Latitude, when *Drake* the *Engliſh*-Man firſt Arrived there, he found the Mountains covered with Snow; and the *Engliſh* were ſo troubled with Cold in the Month of *June*, that they were forced to go from it. Other Iſlands alſo lying in the Ocean, are reported to be liable to theſe Inconveniencies.

At Night, between the Nineteenth and Twentieth Day we ſaw the Sun ſetting in *Calix* at Eleven a Clock and Twelve Minutes, tho' the Horizontal Plane, by reaſon of that unequal part, in which it looks to the *North*, ſcarcely permitted us to determine its true ſetting. We tryed the next Day to take the heighth of the Sun; but this hope vaniſh'd amongſt the Clouds. As much as we can judge from our Journey, and the Sun's ſetting, the Latitude of that place can differ but little from *Torneo*, ſince the Church in *Ca-*

lix, where the Obſervation was taken, ſeems to be ſituate directly to the *Weſtward* of it.

CHAP.

CHAP. VI.

The Latitudes of Places observed in our Return.

ON the 21*st* we observed in the Old Town *Luhlea*, the *Meridian* Altitude of the Sun, and thence gathered the Latitude of the Place to be 65 Degrees, and 25 Minutes. And the Declination of the Magnet from the *North* to the *West*, to be about Six Degrees. That City was Founded in the Year M DC XX II. where there is ſtill an Old Church, yielding to none in that Country, for Structure and Largeneſs; but for a more convenient Situation New *Luhlea* was Built nearer to the Sea, in the Year M DC XL II.

but by the Careleſneſs of the *Laplanders*, kindling a Fire in the Neighbouring Wood, was Five Years after, together with the Wood, deſtroyed by Fire; nor was it Rebuilt more Fortunately after; for in the Year MDCLIII. it was again ruin'd by an accidental Fire, and from thoſe Ruines, became ſuch an one as we now ſee it.

On the 24*th*, in the Old City *Bithea*, we in vain hunted after the *Meridian* Altitude of the Sun, the Sky being thick ſet with Clouds, wholly hindering our Deſign; and therefore we went the next Day into the Neighbourhood, to ſearch for it. This Old City was Built in the Year M DC XXI. but after it was caſually by Fire reduced into Aſhes in the Year M DC LX VI. for ſome time the Rebuilding of it was deferred, until ſome freſh Privileges and Immunities being granted by His Moſt Serene Royal Majeſty, they might undertake the Buſineſs. But the New City then beginning to be Built, is diſtant half a Mile from the Old, being ſitu-

ſituated nearer to the Sea, for a more convenient Port, and convenience of exporting Merchandizes.

The next Day, in the Pariſh of *Schelefta*, near to the Church, we obſerved from the *Meridian* Altitude of the Sun, the Latitude of that place to be 64° 37′ and the variation of the Needle to be equal to the former.

On the 26*th* and 27*th* Days we did nothing, the Air being Cloudy, nor was there any thing which deſerved the noting; except only that the Church of the Pariſh *Bygde*, ſeems to be the moſt ancient of all the Churches of the *Norlands*, provided the Inſcription which appears in the Front of the Church, be genuine, and ſets down the Year of Chriſt, 1169. Yet the Chronicle of thoſe Times takes away the doubt, which clearly ſhow, that it was Founded under the Reign of St. *Erice*, at which Time Religious Worſhip, altho' Infected with Old Popery, made extraordinary Progreſs;

And beſides, there was the Picture of a certain Religious Perſon which was placed in a Wood half a Mile and more from thence; where formerly thoſe who were Remote from Church, are ſaid to have met together to Prayers, on Holy-Days; but after the moſt happy Times of Religion being purged from the Hereſies of Papiſts, as that ſort of Worſhip ceaſed in our Country, ſo the Picture was laid up in a certain place of the Temple, in deteſtation of the Memory of that Matter.

On the 28*th* in *Uhma*, near the Old Temple, we obſerved the *Meridian* Altitude of the Sun, to be 48° 38′. And thence we computed the Latitude of the place to be 63° 48′ but the variation of the Needle not different from the former. That City is ſituated in a more convenient place towards the Sea, and is the firſt and chiefeſt of *Weſtern Bothnia*; in which alſo is the Seat of the Governour of that Province.

On

On the 29*th* leaving that Place, and going thro' the Borders of *Weſtern Bothnia*, which altho' it be more *Northerly*, yet is happy in a more convenient Soil than the Countries next to the *South*, which abound in Mountains, and give place to it in Fruitfulneſs; but the Mountain *Scula* in *Angermannia*, is Famous before all others, very craggy and broken, threatning Ruine, as it were to all who paſs by it, for it is very near to the Highway. Many Stories are vulgarly reported about it, which reliſh only of Gentiliſm. Their only chief City is *Hernoſand*, being furniſhed with a moſt convenient Haven, and is ſituated in the Iſland, where the Seat of the Super-Intendant is, and the Royal-School, the Seminary of the Youth of *Norland*. We ſtayed there three Days, hoping to find the Elevation of the Pole; but this ſtay was to no purpoſe, as in ſeveral other Places, by reaſon of the Rains, and the Sky being covered with perpetual Clouds.

On the 7th. of *July* in the Town *Medelpadia Sundswald*, we endeavoured to find the Latitude of the Place; but Heaven alſo oppos'd it. When therefore all things ſeemed to thwart our Labours, which we cou'd not ſtick long to in one Place for our other Affairs; yet we ſtill continued two days not far from this City in an Inn near the Church *Niurunda*, a Place fit for Obſervations, expecting but with loſt labour the Light of the Sun; and this is the reaſon why at no Place in *Angermannia* or *Medelpadia* we made Obſervations.

On the 10th. of *July*, coming to *Helſingland*, firſt we ſought for the Sun's heighth in *Hudwikſwald*, a neat City of that Country conveniently ſituated near the mouth of the Sea; but without any Succeſs, by reaſon of the imminent Tempeſt.

After

After that, on the 11th. day, we at length found the Elevation of the Pole to be 61° 12′ in another City of that Country, called *Soderhamn*, in a famous Armoury built there. Thence by a crooked way, going to the Copper and Iron Mines, in our Paſſage we firſt obſerved the Elevation of the Pole of the City *Geſle*, being in the County of *Geſtrefland*, 11 miles from *Upſal*, and is famous for being the Seat of the Governor of that Country; and having a Royal School, the Altitude was 60° 31′.

On the 13th. at our coming into *Dalecarle*, or the mountainous Country, the Elevation of the Pole was found at our Inn *Lomſheden*, to be a little greater than before, by reaſon of our Journey's bending to the Northward, *viz.* 60° 41′ going thence through the Pariſh of *Dalicarton Swerdſio*, whoſe Church was firſt beautified with a Monument of a gilded Crown, by King *Guſtavus* of moſt Glorious Memory: Some Antiquities

ties were produc'd here by the Inhabitants; let thoſe who pleaſe believe them in a Matter ſo dubious, and not confirmed by any ancient Monuments.

On the 14th. we came to the City *Fahlun*, very famous and eminent for being the Seat of the Governour of that Country; and eſpecially being the richeſt in Copper Mines, of ſo great Antiquity, that the Original of it is very uncertain and doubtful. From this City which we arrived at with ſo many Windings and Turnings, we did not think it convenient to depart without an Obſervation; therefore ſtaying there ſix days before the Sky was as agreeable as we wiſh'd, at laſt the grateful Light ſhone forth on the 20th. of *July*, by help of which we found the Meridian Altitude of the Sun, and by it the Places Latitude to be 60° 32′; and therefore perceived this City to lye almoſt in the ſame Latitude as *Gefle*.

After

After that designing to bring our Journey to an end, (without any Observation because of Showers and Storms) we passed the several Cities of *Westmanland* and *Hedenore*, so well known for its Merchandize, Agriculture, and Fairs; and then *Afwestafors* famous for Copper Mines of several sorts, and coining of Moneys; and then to *Soleburg* a very noble Place, and celebrated for one of the most precious and ancient Mines of Silver.

Happily returning to *Upsal* on the 24th. of *July*, the Situation and Antiquities of which City being described by others, are well known to all People; but the Elevation of that Place's Pole is 59° 54′ for ten Years, and more at several times observed by me, and the Variation of the Compass about eight degrees.

Be-

Becauſe we were ſenſible at our return, that our moſt Serene King was at *Kongſor*, to Review his Army, to whom we were to give an Account of our Expedition, we thought fit to wait on His Moſt Serene Royal Majeſty there; and therefore ſetting our Affairs in Order in two Days, on the *27th* we paſſed thro' the City *Enecopia* in *Upland*, and the Cities of *Aroſia*, *Koping*, and *Weſtmanland*.

On the *28th* we came to *Kongsor*, in that moſt pleaſant place of *Sudermanland*, to the Latitude of 59° 34'. ſituated by a moſt pleaſant River, where it empties it ſelf into the Lake *Galtem*, and *Malaren*.

His Moſt Serene Royal Majeſty received us at our Coming with a ſingular Clemency; and as we gave him that Account of the demanded Expedition, hearkned to us with a Countenance full of Grace and Majeſty;

ſty; and the Moſt Serene Hereditary Prince, and ſome of the King's Council, and great Miniſters of State being preſent, He enquired much about our Demonſtrations; and would have the Reaſons of the moſt minute Matters laid before him; but we wondred at nothing more, than that the Moſt Serene King being loaded with ſuch a weight of Empire, and perplexed with infinite Cares, ſhou'd, of all the things which he ſaw or heard the Year before, in the *Northern* Countries, forget nothing; ſo that we but juſt returning from thoſe Places, and doing no other Buſineſs, did not ſeem to have a freſher Memory of Things, Events, Places, Perſons, and of the Names of Towns and Houſes, which we beheld as if we were preſent, being juſt come from our Journey, and Inſtructed with our Journals: but what need of our Teſtimony in a Thing ſo well known in our Country? Thoſe whom God hath Exalted upon Earth to ſo high a Place, he hath thought fit to endue with Divine Gifts; which

which certainly He hath beſtowed with a full Hand on our Moſt Gracious Monarch.

The next Day being diſmiſſed moſt favourably by His Moſt Serene Royal Majeſty, we heartily Rejoyced that we had obtained the heighth of our Wiſhes, that our ſlight Labours ſeemed not to diſpleaſe our Moſt Gracious Maſter; and now having diſpatched this Buſineſs, every one went to his own Home.

Homer relates of his *Vlyſſes*;

πολλῶν ἀνθρώπων ἴδλεν ἄσεα καὶ νόον ἔγνω.

But who can believe that we traverſed ſo many Cities in this Journey; and *Northerly* waſte Part of *Sweden*; going no more than Five Miles beyond *Kongsor*, thro' *Holmia*, before we came to *Vpſal*. We ſaw beſides the ſaid Cities *Orebro*, *Arboga*, *Torſhella*, *Strangnans*, *Mariefred*, *Sodertelus*, and *Stockholm*.

holm. So that in all we passed thro' Twenty Four of them in a direct way.

CHAP.

CHAP. VII.

The Figure of the Earth, Variation of the Needle, and difference of Refractions under the Pole and Æquator.

NOW altho' in this Journey, but a little may ſeem to be Remarked, which may pleaſe a Curious Reader; yet there are ſome Things, which amongſt Juſt and Learned Criticks, will at leaſt Excuſe, if not Commend our Labour; for as to what concerns Chorography, that by Command of His Moſt Serene Royal Majeſty, is deſcribed with the greateſt Care, by the Surveyors

ors of those Countries, who for some Time had the Charge of it. The Antiquities of the several Provinces are not slightly discussed by the most Learned Antiquaries of the Kingdom, therefore Astronomy was only our Point, in which if we have performed nothing else, we have really shown, that all those Places in which we made Observations, being laid down too much to the *Northward*, both in our Maps and Charts, ought to be more *Southerly*. And this very Thing hath been before observed by those who Sail to the *Northern* Parts, about the Promontory of the *Northern* Cape; which in their Opinion is more *Southerly*, than is described in the Geographical Tables.

As for the variation of the Compass, altho' by reason of the Impediments before expressed, we cou'd not describe it so exactly as we ought; yet we may assert for certain, that in all those Places we had the Fortune to go to, it was never found less than Six Degrees,

which Experiment may be ſerviceable to Poſterity who may obſerve the Conſtancy of its Declination ; for it is very probable and agreeable to Natural Cauſes, that its Declination is changed with the Time ; as the Experiments and Obſervations of Mathematicians made in very many places, many Years ſince, do abundantly teach us.

There yet remained one thing which rendered us very ſollicitous, though in vain, of which we conceived an ample Hope at our departure, *viz.* That in theſe more *Northerly* Voyages, an occaſion is given of enquiring into the true Figure of the Earth, which altho' no Body who hath a ſound Head, at a Time of ſo great an Improvement of Mathematicks, will make to be Triangular or Cubical, ſince the Superficies of the Water and Earth returning into it ſelf hath long proved it to be Gibbous. Yet ſince there are ſundry ſorts of Gibbous which ariſe from a Cone or Cylinder, if it goes from a Cir-

Circular, 'tis doubted to which of theſe it is to be chiefly referred.

We have ſpoke before of the Experience of Sailors, to whoſe Credit and Relations we owe the aſſerting the Roundneſs of the Earth, but only to convince the obſtinate Heads of ſome People, who truſt more to their Senſes than Underſtanding. For Mathematicians have demonſtrated this very Thing many Years ago, by other, and thoſe moſt evident Reaſons.

All know the Story that *Ferdinand Magellanus* Sailing out of *Spain* towards the *Weſt*, and having paſſed the *Atlantick* Sea, by a ſtrait he found out, got into the *Eaſtern* Ocean, and by that way came to the *Moluccos* Iſlands; in which Voyage, when he had ſufficiently view'd enough that Country, he might have return'd by the ſame way: But not contented with that Experiment, he went farther to the *Weſt*, by a direct continued Courſe; at length returning as it were out of

the *Eaſt*, by the *Indian* Ocean, and *Atlantick*; and leſt any ſhou'd think, that the Face of the Continent is different from that of the Waters, let him conſider, that the Ocean is diſtinguiſh'd by Lands, from the *Eaſt* to the *Weſt*; and on the contrary, by Seas betwixt them; and again, flowing into the *Northern* Land, above and below *Tartary*, whence ariſe ſo many Continents as if they were Iſlands, ſcarcely cohereing any where by the moſt narrow *Iſthmus* which every where almoſt have the ſame heighth. For here is no Controverſie about the Mountains or higher Places in the Earth, which no more hinder its being round, than the ſmall Inequalities in an Apple; ſince we will grant to any, that its Superficies is not moſt exactly round; for Nature ſeldom makes Mathematical Circles in its Motion; but if the Motion of the Sun were altogether Sphærical near the Æquator, which we know to be inequal, altho' it is ſuppoſed to be equal; for the Earth is not the Center of that Motion; yet would it not follow, that a Sphere is formed by Motion, equally near

near the Poles, as the Æquator; for the Experience of Artiſts ſhows, that Cups turned, may imitate another Figure than Spherical.

It is not to no purpoſe therefore, that ſome in this Age doubt whether the Earth be equally Spherical near the Poles as the Æquator. Some of the Reaſons which *John Childrey* brings in his *Britannia Baconica*, for the Oval Figure of the Earth, are not to be deſpiſed; altho' we do not much approve of that which is brought from the Snows being gathered together in a great heap near to the Poles, ever ſince the Creation of the World.

It is certainly true, that in *Lapland* very old Snows, of many Years ſtanding, are found in the Vallies between the Mountains; as may be gathered from their outward Coat Yearly remaining: And yet, no doubt, ſome of this Heap is Yearly diſſolved into Water. But thoſe heaps of Snow make no more for taking away the Round-

neſs of the Earth, than the Riſings of thoſe Mountains we before mention'd; but beſides, if this was true, there ought to be the ſame Acceſſion of Snow every where about the whole Globe of the Earth, which the Induſtry of thoſe who going to Eighty Degrees Latitude, found Mountains cruſted with Ice in that Sea: Tho' in time diſſolvable by the violence of a Tempeſt, forbids us to aſſert of Maritime Places.

Better Arguments might be brought from the Diurnal Motion, and the Nature of Cœleſtial Vortices, which peradventure wou'd produce ſome variety in a Spherical Figure; ſo that this Hypotheſis ſhou'd not ſeem to be altogether neglected, eſpecially ſince amongſt Oval Figures, by reaſon of the ſmall difference of Diameters, almoſt Parallel at the Section of a Cone or Cylinder, they do not much differ from the Figure of a Circle. *Caſpar Eiſenſchmit* hath therefore confirmed this Argument with great probability, and illuſtrated

it

it with the Demonſtrations that were needful. Of which at preſent we muſt ſay no more, ſince it requires a ſeparate Work and Demonſtration aſſuredly. In our Journey we long ſought after ſome places of the Earth, ſituate in ſome Plain, ſtretching from *South* to *North*, by advantage of which we might Be more certain of the true meaſure of Degrees in *Northern* Latitudes, and by comparing them with the more *Southerly*, collected by the Pains of others, we alſo might give our Judgment of the Figure of the Earth; but the ſteep tops of Mountains, the Mooriſh Grounds, and inacceſſible Woods, render'd our Deſires unſucceſsful.

Laſtly, We hope that this our little Work will not be unacceptable to Mathematicians abroad; tho' it were only for that Doctrine of Refractions, lightly attempted; from which occaſion, they will not diſapprove of our Opinion to make Tables of them in the ſeveral Parts of the World. For as we do not at all doubt that they increaſe

according to the different Account of Elevations in places nearer to the Poles; ſo in thoſe placed in the Æquator, and next to it; if there ſhall be any Refractions, we believe they will be very little. And from hence, when the Reaſon is asked, why the Polar Stars are not ſeen by thoſe who Sail under the Æquinoctial; and yet it is probable, that the Stars placed in the Æquator may be diſcerned from the Poles, if there was any Obſerver. We think that, amongſt other Reaſons, this of Refractions is not of the leaſt Moment.

And if it be true which *Mandeſlo* aſſerts in his Travels, in the Thirteenth Chapter, that he ſaw not the Arctick Pole, except beyond the Sixth Degree, on this ſide of the Æquator; but the Antartick beyond the Eighth. It follows, beſides other Reaſons, that the Refraction from the Northern Part of the Earth; is greater than from the Southern, To Confirm which, we cou'd bring many probable Argu-

ments,

ments, if the Matter was to our purpose.

Νῦν δ' ἄλλῳ τοῖς θέσιν ἀνὴρ ἐπιτέρπεται ἔργοις.

Αὐτὰρ ἐμοὶ τὰ φίλ' ἐστι τά πε θεὸς ἐν φρεσὶ θῆκε.

FINIS.

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